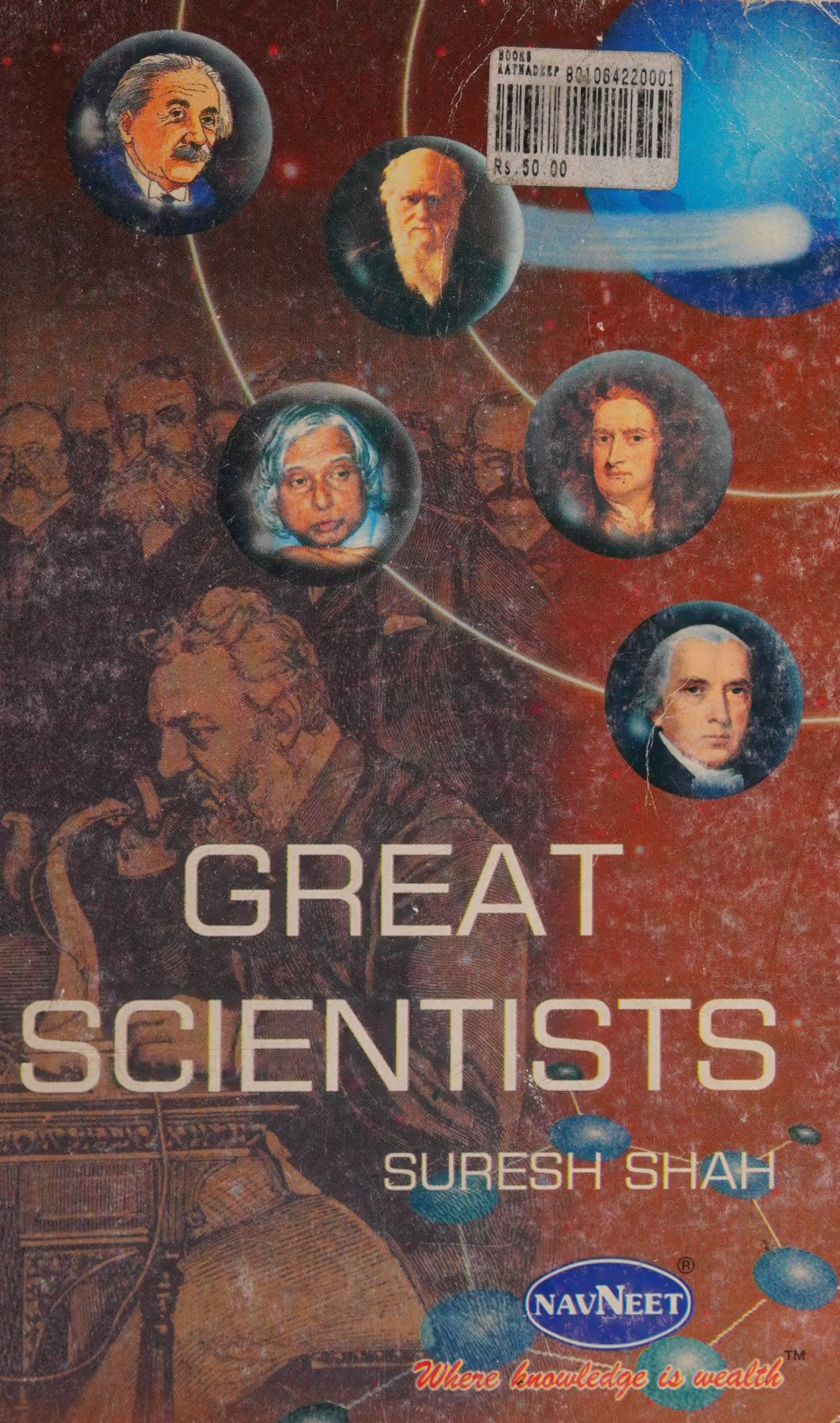


GREAT SCIENTISTS

SURESH SHAH

NAVNEET®
Where knowledge is wealth™

DR M N DESAI
MSc., PhD., DSc.

Co-ordinator,
Self Finance Courses,
Gujarat Law Society, Ahmadabad.

Former Vice-Chancellor,
M S University of Baroda, Baroda.
Gujarat University, Ahmadabad.
Dr B A Open University, Ahmadabad.

I have gone through the book 'Great Scientists' by Prof Suresh Shah. The selection of scientists, their lives and detailed description will indeed inspire our students and teachers. The book has been written in simple and lucid language. I observe this book as an attempt to help cultivate scientific point of view and understanding within our society. I recommend this book to students of science and other streams.

I congratulate Prof Suresh Shah for writing this book.

12-02-2003
Ahmadabad

(DR M N DESAI)

Dedication

This book is dedicated to respected Prof Dr K R Ramanathan, from whom I received research guidance and training in several fields. I am happy to dedicate this book to his fond memory.

GALA

AN INSPIRING PUBLICATION

GREAT SCIENTISTS

[STUDENTS, TEACHERS AND READERS MAY SEEK INSPIRATION, GUIDANCE AND CULTIVATE A SCIENTIFIC TEMPER IN PURSUIT OF EXCELLENCE]

Author

Suresh Shah

NAVNEET®

NAVNEET PUBLICATIONS (INDIA) LIMITED

Navneet House, Gurukul Road, Memnagar, Ahmadabad-380 052. Phone : 743 6300/743 9300	**Navneet Bhavan,** B. S. Road, Dadar, Mumbai-400 028. Phone : 5662 6565

Dhanlal Brothers Distributors

70, Princess Street, Mumbai-400 002.

Phone : 2201 7027

Visit us at : www.navneet.com • www.connectschool.com

G 3665

e-mail : npil@navneet.com

Price : Rs. 50.00

ABOUT THIS BOOK...

It was Dr Sudhirbhai Pandya (Retd. Director, PRL), Founder-President, Gujarat Science Academy, who invited me to write a book on the life and works of Sir C V Raman and the book *'Prakashni Pankhe'* was published. Thereafter, for long, I thought of writing about scientists from India and abroad.

Meanwhile, Navneet Publications (India) Limited gave me an opportunity to write a book on Great Scientists, which I readily accepted. I am happy to present my humble and sincere effort through this book, the lives and works of eminent scientists. In the book **21** scientists are from India and **38** from abroad and their lives and works are depicted, in an interesting manner. It is said that biographies of great personalities contribute to the life and character-building of an individual. I hope and wish that you, the reader too, may carry out such meritorious and inspiring work in your life.

I sincerely thank Navneet Publications (India) Limited and it is through their joint effort and kind cooperation, that I have been able to prepare and complete this book. I am thankful to Mr Anil Pillai for adaptation of this book in English. I also thank Mr A V Namjoshi, Mr Balubhai Patel and Mr Amarashish Phanse for their valued suggestions. Any constructive suggestions for content-improvement are welcome.

–Suresh Shah

CONTENTS

(A) INDIAN SCIENTISTS

(B) FOREIGN SCIENTISTS

(A) INDIAN SCIENTISTS

1

Sir Jagadish Chandra Bose

Jagadish Chandra Bose, the great Indian scientist who made the world aware that "plants too have feelings", was born on November 30, 1858, in Mymensingh district of Bangladesh (East Bengal in those days). His father Bhagwan Chandra Bose was the Deputy Magistrate of Faridpur district. He spent his childhood in a family steeped in Indian culture and tradition. Right since childhood, the great Indian epics the *Ramayana* and the *Mahabharata* influenced him. These epics became his constant source of inspiration. He believed in the fact that hard work can turn failure into success.

He did his schooling at St Xavier's School, Kolkata (Calcutta). At school many of the students were British and Anglo-Indian as well as children of officers. Seeing this village boy they thought of harassing him. Initially, Bose tolerated their abuses and misbehaviour. But later, not able to tolerate them any longer, he fought with a well-built boy and pinned him down. After this win, many students became his friends and started treating him with respect. Now, nobody dared to harass him.

He had his college education in Kolkata. He later went to England to study medicine. Impressed by the famous physicist Lord Rayleigh in England, he changed track from the field of medicine to physics. He enrolled himself at Cambridge's Christchurch College and in 1885

obtained a DSc degree from London University. With tripos in natural science, he returned to India.

He joined the Presidency College in Kolkata as professor of physics – the first Indian to hold such a high post. After joining service, he came to know that he was offered less salary compared to his British counterparts. He refused to accept the salary and protested against this injustice; though he continued to perform his duties.

Raising his voice against injustice was a kind of *satyagraha*. His *satyagraha* had an effect on the government and they conceded to his demand, finally. He was given all the outstanding salary due to him. Before Mahatma Gandhi came to India and made us realize that injustice could be fought through *satyagraha*, Bose had successfully experimented with this type of protest in a peaceful manner.

When a ray of light passes through a crystal, it is refracted, i. e. it bends and changes its course. In some crystals there are two refracted rays. This phenomenon is termed as double-refraction. After coming to Kolkata, Bose started research on double-refraction. His first research paper on double-refraction was published in the *Journal of Asiatic Society of Bengal*. Later, he started work on electromagnetic waves. He undertook research studies on production, transmission and reception of electromagnetic waves, with wavelengths ranging from 1 mm to 1 cm. Generally, working on this range of wavelength in those days, was indeed considered very difficult.

In this regard, he received neither instruments nor any support from his college. Nonetheless, he put local artisans on the job and under his guidance they constructed instruments at his expense and in three months he began his research. It was for the first time, he used microwaves to understand the structure of substances and met with success. The device he designed

is today known as 'waveguide'. Bose's experiments on the quasi-optical properties of very short radio waves (1895) led him to make improvements on the coherer, an early form of radio detector, which have contributed to the development of solid-state physics.

Before Guglielmo Marconi, the famous Italian inventor and electrical engineer associated with wireless telegraphy began work in this field; Bose had already begun research in this difficult area and was successful to a considerable extent. In 1895, Prof Bose had demonstrated in public that radio waves can be transmitted through a solid wall. This public demonstration made him famous. At the Royal Institution London, in the presence of Lord Kelvin and other famous scientists, Bose demonstrated this experiment again. He later gave up experiments in this area and shifted attention to the study of botany. Many years after this public demonstration, Marconi patented the rights to his wireless experiments. Today, many foreign books eulogise Marconi as the pioneer of wireless, but its real credit should go to Bose.

Research was a daunting task for Indian scientists during the British rule. There was a shortage of instruments, lack of laboratories with necessary facilities. Reference material and libraries too were unavailable. With no encouragement forthcoming from the government, they had to set their sights on London for recognition. Bose's intellectual prowess had impressed many English scientists. Among them, Lord Kelvin and Sir Oliver Lodge had a lot of respect for Bose. They even went to the extent of suggesting that Bose settle in London and conduct research there. But, Bose was a patriot who did not welcome this idea.

By the turn of the century, Bose was totally engrossed in the science of plant physiology. He developed a novel method to study micromovements in plants when they are stimulated. He proved that plants too have feelings

or sentiments and like human beings they too tend to react in a particular way to pain and pleasure. Like man or animal, a plant cannot express pain or pleasure by voicing, wailing or shrieking. But it can flower, wither, sway and thus express its feelings. Like other living beings, plants too breathe.

On May 10, 1901, the lecture hall at the Royal Society of London was packed with scientists. Bose was to demonstrate one of his important experiments. He had devised a very sensitive instrument called the crescograph to test the sensitivity of plants. It was a unique instrument and invention. The instrument was attached to a plant. The plant was then dipped in a container filled with bromide poison. On the screen could be seen the pulsations of the plant. Slowly, the pulsations became erratic and stopped abruptly, as if the plant was poisoned to death. There was an air of surprise all around.

[**Crescograph:** A super sensitive instrument for recording plant growth by magnifying a small movement as much as ten million-fold.]

Many plant physiologists were not happy with this outcome. They were peeved and angry for Bose was a physicist who had transgressed or ventured into another area. He had also scuttled the principles of many plant physiologists. They became so disturbed and agitated that they even opposed publication of his speech by the Royal Society. But, Bose was not one to take things lying down. After two years of hard work, he published a monograph–'Response in the Living and Non-living'. With this monograph he convinced the Royal Society that he was indeed right. The speech that was not initially published by the Royal Society was now published and

sent the world over. Bose had become a world-renowned scientist. He received many awards. In 1920, he was elected Fellow of the Royal Society. He became the first Indian scientist to be elected to that position. Taking into account his valuable contribution, the British Government conferred the title 'Sir' on him. Thus, he came to be known as Sir Jagadish Chandra Bose.

Bose now came to be recognized as a biologist. Indians will always cherish his valuable contributions. Only after the West recognized his research works did the people in his motherland come to realize the greatness of this man. On November 30, 1917, Bose dedicated Bose Research Institute to the nation.

Poet Rabindranath Tagore was Bose's friend. During this period, the West was not aware of Tagore. Bose translated many of Tagore's works and published them. His literary talent came to the fore here. Bose was about 30 years elder to Sir C V Raman, another great Indian scientist. It is a matter of coincidence and belief that Bose set the physics paper of the 'Financial Civil Service' examination for which Raman appeared. A day before his death, he instructed the Superintendent of the Bose Institute to dispose of his residuary properties to endow research and social work.

On November 23, 1937, at Giridih in Bihar, this great scientist breathed his last. His books include Response in the Living and Non-Living (1902) and The Nervous Mechanism of Plants (1926). Even today, the Bose Institute set up by him runs on his ideals and is progressing in various research fields, raising his name and taking the institution to new heights.

2

Acharya Dr Prafulla Chandra Ray

Acharya Dr Prafulla Chandra Ray, India's great chemist and scientist, was born on August 2, 1861, into a prosperous and cultured family in Bangladesh's (previously East Bengal's) Radouli Katipara village. His father, Harishbabu was one of the founders of the western education in Bangladesh. He had established the Model English School. Social reformers of those times like Jatindra Mohan Tagore, Ishwar Chandra Vidyasagar and others were his close acquaintances. As a child Prafullababu, though of delicate built, was an intelligent boy. After primary schooling in his village, he joined Kolkata's (Calcutta's) Heyer School in 1870. Though he excelled in studies, poor health forced him to discontinue studies in 1874. But he continued reading, which was his passion for life. As health improved, he was admitted to Kolkata's Albert School. In 1879, he cleared the entrance examination and joined college at Kolkata University.

For higher studies he joined Metropolitan Institute founded by Ishwar Chandra Vidyasagar. Later, he joined the Government Presidency College in Kolkata. He was fond of literature. Apart from English, he also acquired mastery over Latin, French and Sanskrit. The life sketches of great personalities interested him. He once came across the biography of Benjamin Franklin (American scientist, known for his experiments in static electricity), which influenced him profoundly. He then developed an interest in science. Meanwhile, he appeared for the competitive

examination for the Gilchrist Scholarship held in India and was selected for the Scholarship award. With great difficulty he convinced his mother to grant him permission to go abroad. His father had already expressed happiness over this decision.

In 1882, Ray left for England to study science and joined the University of Edinborough. There, he came in contact with the famous chemist Alexander Brown and his interest towards chemistry deepened. He also came into contact with famous scholars–Dr's Gibson, Dobbin and others. He studied the German language and read works by German scientists. He also met the then famous Indian scientist Jagadish Chandra Bose. They became good friends. After acquiring his BSc degree from the University of Edinborough in 1885, he undertook research in the analysis of base metals and acquired his DSc degree in 1887. He also won a few prizes and scholarships at the University of Edinborough. In 1888, he was selected as the vice-president of the university's Chemical Society. After these shining achievements, he returned to Kolkata in 1888 and joined the Presidency College as Assistant Professor drawing a salary of Rs 250 per month.

At college, besides teaching, he took up research in various nitrites. He lived a simple life, gave up western clothing and wore the traditional Indian dress (*kurta* and *pyjama*) at college. Whatever he earned, he spent on science related activities and in helping the needy. At home, he set up a small laboratory. In 1895, his first major discovery, the making of mercuric nitrate was announced. This discovery drew attention of the scientists all over the world, carrying out research in chemistry. Concerned about poverty in India, he believed that setting up of chemical and pharmaceutical industries would not only provide gainful employment, but also make our country self-reliant. Besides, such efforts could save many lives lost due to lack of medicines.

He wished to set up small and big industries for the unemployed science graduates. In 1901, he helped to establish the Calcutta Pottery Works to manufacture China clay pottery. Besides, he also established the Bengal Chemicals and Pharmaceutical Works Ltd. For this purpose he also set up a trust. This proved to be a boon to the country, especially to Bengal. Initially, it helped the chemistry graduates of the Presidency College and other such students to gain employment and become independent. His second major discovery was ammonium nitrate. For his successful research in nitrite he was conferred the title *Master of Nitrite* by Prof Armstrong. His research in nitrite drew worldwide attention. Inspired by his impressive achievements, in 1904, the Bengal Government sent Ray to various laboratories of European countries on a study tour. During this study tour, he also delivered lectures on his research. Moreover, Ray's book *Indian Chemical History* published in 1902, became a much talked about book in the world. The Chancellor of Durham University praised the book. Ray wrote in detail about the work carried out by Indian chemists of the 13th and 14th century. The book gave a true picture of the Indian culture.

In 1911, the government conferred on him the Knighthood. In 1912, as representative of Kolkata University, he toured Europe to participate in the first conference of universities. The same year Durham University honoured him with the Doctor of Science degree. In 1918, he accepted an invitation from Chennai (Madras) University to deliver lectures. He donated the entire honorarium amount he received from the university as scholarship for the benefit of students.

He was appointed president of the Indian Social Conference held in Kolkata in 1917. He became the chairperson of the Indian Science Congress held in 1920. The same year he got an opportunity to meet Gandhiji.

Deeply influenced by the Gandhian ideals and the *Khadi* way of life, he became an ardent supporter of the non-violent struggle. When a severe drought hit Khulna district, Ray left all his work and rushed there to take part in relief activities. He popularized the use of *charkha* as a means of employment among the poor. He explained the *charkha* economics in a novel way.

In 1921, when he completed 60 years, he donated his entire salary to the university, for the development of science and technical college. From the interest accrued on Rs 1,30,200 every year, two students are awarded the Dr P C Ray Scholarship. In 1922, he announced the Nagarjuna Award with a donation of Rs 12,000 and the 'Sir Ashutosh Mukherjee Award' with a donation of Rs 11,000 for the best students of microbiology and life sciences respectively. There are people who donate money as scholarship for students, but rarely will one find people who spend their money on scholarship in the name of others. They are truly great.

Sir Ashutosh Mukherjee was the Chief Justice of Kolkata (Calcutta) High Court. He was later appointed the Chancellor of Kolkata University. Taking into account Sir Ashutosh Mukherjee's tireless efforts to raise the standard of science education at the university and his contribution to science, Ray decided to announce a scholarship in his honour.

In 1924, Ray, J N Mukherjee, J C Ghosh and Shanti-swaroop Bhatnagar joined hands to form the Indian Chemical Society. Ray made an initial contribution of Rs 12,000 towards the institute's expenses. He was the president of the society for two years.

In 1932, Ray wrote his autobiography titled *The Life Sketch and Experiences of a Bengali Chemist*. In 1934, the London Chemical Society honoured him by offering him honorary membership. He retired from the university as a Palit Professor of Chemistry in 1936. Commending

his services, the university appointed him as Professor Emeritus for life. He was a sage-like professor – a soft-spoken, affectionate and compassionate human being.

On June 14, 1944, this great Indian scientist breathed his last within the university premises. The last rites of this scholarly scientist were performed near the place where Guru Rabindranath Tagore was laid to rest. Let us pay homage to this multifaceted, heroic personality who sacrificed everything for the nation.

3

Sir Vishweshwaraiya

Mokshagundam Vishweshwaraiya, India's topmost engineer and scientist whose name resounded throughout the country, was born on September 15, 1861 in Madanhalli village near Bangalore in Karnataka. His village was located near the Kolar gold mines in Mysore. His father's name was Srinivas Shastri and mother's name was Venkchaiya. His parents were loving and God-fearing. The family was not financially well-off. But his mother had instilled good values in him.

He studied at the village primary school. He was a bright, able and brilliant student. Teachers were impressed by his exceptional intelligence. For his high school education he came to Bangalore where he took admission in the Central College. Aware of his father's financial constraints, he gave tuitions to children to earn some money. He completed his BA in 1881.

Impressed by his brilliance and keenness to study, the principal of the college got him admitted at the engineering college in Pune (Poona) and also recommended his name for scholarship. With his financial worries put to rest, he could now concentrate more on his studies. His principal subject was mechanical engineering. In 1883, he graduated with mechanical engineering from Mumbai University with first rank. For his achievement, the Mumbai government appointed him as an assistant engineer in 1884.

He joined the engineering department at Nashik (Nasik) and took charge of his duties with enthusiasm and dedication. Gradually, he groomed himself into an able engineer. Seeing his dedication and perseverance, in 1894, he was given charge of overseeing the construction of Sakkar Barrage in Sindh. Meanwhile, he got promoted to the post of superintendent engineer. He successfully completed the construction of the Sakkar Barrage on time. The construction of this dam work was considered tough and testing. The government too, had put faith in him and handed over charge of construction. With the completion of the dam work, he now came to be recognized as India's most competent engineer.

He then successfully completed water supply projects in Vadodara (Baroda), Karachi, Pune, Kolhapur, Sangli, Surat, Nashik, Nagpur and other cities. He became renowned all over the country and got quick promotions. In 1906, the government sent him to Aden to study the water supply facility there. He studied the drinking water supply project there and thought of how best we could implement it keeping our conditions in mind.

His success and speedy promotions soon became the envy of his fellow engineers. The atmosphere had become vitiated. He decided to break free from these surroundings. Finally, he resigned from the government service. However, the government gave full credit to him. Even though he

had not completed the qualifying years of service, the government decided to grant him full pension.

Soon after his resignation, he left for Europe. Meanwhile, the Nizam of Hyderabad sent him a word to return immediately. Vishweshwaraiya was requested by the Nizam to build a dam on the Musi river, which caused lot of destruction due to frequent floods. Since the project was for the people's welfare, he accepted it. He developed projects suitable to control the Musi and Esa rivers and successfully completed them on time. This resulted in averting large scale destruction of houses, goods, agriculture and human lives. Agricultural produce increased with regular and uninterrupted supply of water. When this work was completed, King Krishnaraj of Mysore invited him to the state. He was appointed the chief engineer of the state. He held the post for three years. Pleased by his work, the king appointed him as the Diwan of the state. He served for six years in Mysore. He built the Krishnaraj Dam on Kaveri (Cauvery) river and created the world famous Vrindavan Gardens there. Within a span of six years, he developed Mysore into a top class city. He founded Mysore University and Mysore State Bank. Moreover, he also contributed towards the industrial progress by establishing the Bhadravati Iron Works, cement factory, paper industry, sandalwood oil industry, soap industry, etc. Thus, it was Vishweshwaraiya who led Mysore state on the path of progress.

He resigned from the post of Diwan and left for a trip abroad, to study modern architecture and get first hand experience of engineering science. In comparison to other countries, he felt, India lagged far behind. After his return, to take advantage of his new experiences, he was appointed member of several committees. Meanwhile, the Bhadravati Iron Works was facing problems. At the king's

request he took charge of the factory and set it on course. Probably, it was for this reason that Jamshedji Tata invited him to Jamshedpur to become a member on the Board of Directors of the Tata Iron & Steel Works Ltd. He rendered his services there till 1955.

Vishweshwaraiya was not only a competent engineer, but also an able administrator. He also took care of the country's economic condition. In this regard, he published a book in 1934, which received high acclaim. Some famous books written by him are: *Reconstructing India* (1920), *Planned Economy for India* (1934), *Prosperity through Industry*, *Memoirs of my Working Life* (1960). The British government honoured him with the title of 'Sir'. Many universities also awarded him honorary doctorate degrees. He received laurels from all over the country. In 1955, the Government of India conferred on him the *Bharat Ratna*, the country's highest honour. Dr Rajendra Prasad, the then President of India, invited him to stay at the Rashtrapati Bhavan for ten days. But, Vishweshwaraiya being a disciplinarian believed that an invitee should not stay for more than three days.

On September 15, 1961, he completed hundred years of his life. His centenary was celebrated with much fanfare, publicly and privately. When asked on that day about the secret of his long life, he said it was his punctuality and control over anger. On the occasion of his birth centenary, Pandit Jawaharlal Nehru, the then Prime Minister of India, said, "Vishweshwaraiya speaks less and works more." This great scientist breathed his last on April 14, 1962. We pay our tributes to this great scientist and engineer of India.

4

Prof Tribhuvandas Gajjar

Constantly striving to improve people's lives through handicrafts–arts and crafts industries, Tribhuvandas Kalyandas Gajjar was India's great scientist and Gujarat's first and foremost chemist. He was born in August, 1863, in a well-to-do and prosperous Gajjar family of Surat. His uncle, Atmaram Gajjar was a well-known personality. Atmarambhai's ancestors, who belonged to a carpenter family, had earlier settled in Dhanasuthar's Pole in Ahmadabad. A square named Gajjar square still exists there.

Tribhuvandas' father Kalyandas was a well-known sculptor. He had also written a book called 'The Art of Sculpture'. Tribhuvandas was the youngest of four sons and two daughters of Kalyandas. Intelligent as a child, he went to the city's primary school. He cleared every class with high grades. Tribhuvandas' father was pleased with his brightness. At home, he taught Tribhuvan the art of sculpting. Thus, Tribhuvan learnt intricate wood carving and obtained knowledge of the traditional art of sculpting from his father. When he was 16, he cleared the matriculation examination with good marks. While at school his interest turned towards science. For higher education, he joined the science stream of Mumbai's (Bombay's) Elphinstone College. Chimanlal Setalwad and Keshavrai Harshadrai Dhruv were his classmates. He got 75% marks in BSc with chemistry as his principal subject. For this achievement, he was appointed junior fellow during his postgraduate studies and later, senior fellow,

in the college. As a junior fellow, he taught chemistry and physics to freshly admitted students. He then completed his MA from Mumbai University.

India's economic condition had worsened during the British rule. With the intent of helping society during these trying times, he came to Surat and started the cottage industry school. His aim was to guide the youth in various skilled work based on science, ultimately to make them self-reliant. But later on, due to lack of government aid and funds, he had to wind up this school.

Meanwhile, he was invited by the then Mumbai Government to join Sindh College in Karachi as professor of chemistry with a salary of Rs 300 per month. He was also invited by Vadodara (Barôda) College for the same post with a salary of Rs 200 per month. Since the Maharaja of Vadodara, Sir Sayajirao Gaekwad encouraged cottage industry, Tribhuvandas decided to join Vadodara College even though the salary would have been less than what he would have got at Sindh College.

After joining Vadodara College, he won the hearts of one and all with his knowledge, enthusiasm and dedication. There, he skilfully carried on his work. Some time later, an order was issued to send him abroad along with a few bright students for further studies. He was to be sent abroad for further study in farming and after his return, he would be made deputy collector in the revenue department. He convinced his superiors not to send him abroad and showed his readiness to take up printing and dyeing work in the state. For this purpose, he carried out a survey and set up a laboratory. He started giving scientific training to the youth of the families engaged in dyeing and printing. There was a good demand for these trained artisans. In this venture, he received support of the Maharaja and the people as well. He met the Maharaja and apprised him of the importance of

setting up a training school like Kala Bhavan for cottage industry.

In June 1890, Kala Bhavan was established in Vadodara and its entire responsibility rested on Gajjar's shoulders. A special fund for this purpose was also handed over to him. In a short time span, 800 students had joined the school. Working very hard, he introduced courses in carpentry, drawing, architecture, building construction, weaving, dyeing, chemistry, physics, etc., and started imparting knowledge. He provided free boarding and lodging to economically weak students. It was his earnest desire that our country should match other countries in cottage industry and also in the field of science. After overcoming teething problems, he started thinking ahead. He found it essential that necessary study material be written and published in the vernacular language. He also obtained the Maharaja's permission in this regard. Maharaja Sayajirao granted him permission to spend up to Rs 50,000 on that venture. For this purpose, he also developed a dictionary. Professor Gajjar also knew the German language. He translated German books and periodicals on cottage industries in Gujarati and published them in his magazine *Rangrahasya* (Colour secrets). This helped in teaching new techniques to the students. Gradually, the demand for students who passed out from Kala Bhavan increased. In five years, the Kala Bhavan became the soul of Gajjar. But, due to false propaganda by some envious elements he had to resign from the institute in 1896. He then went to Mumbai.

After coming to Mumbai, he joined Wilson College as professor of chemistry. There, he contributed towards improvements in the field of education and modernised the curriculum. Meanwhile, Mumbai was in the grip of plague and no medicine proved to be effective. Gajjar developed a medicine called iodine terchloride. This medicine proved to be very effective. He was opposed to

the idea of grabbing the opportunity to patent the medicine and make some fast money. He placed the medicine before the world. His only intention was to serve the poor people.

In 1898, at his own expense, he set up a private laboratory named Technochemical Laboratory. Gradually, he expanded the institute with more facilities. Later, Mumbai University and Grant Medical College granted recognition to this laboratory for their students.

Meanwhile, in 1898, an incident took place that made Gajjar famous the world over. It so happened that in Mumbai's walled city area on Esplanade Road, someone had blackened the face of the marble statue of Queen Victoria. The colour was permanent and it was difficult to remove it. The British government was in a hurry to clean up the statue, but they were unsuccessful. Experts from the world over were called in, but failed to clean it up. At this stage, Gajjar showed his willingness to remove the stains. The government summoned Gajjar and asked him to clean up a part of the statue. He successfully did it and went on to remove all the stains. Newspapers all over the world hailed Professor Gajjar's efforts. He became world-famous and gained recognition internationally as a chemist.

After this, Gajjar made such an amazing discovery that he received both wealth and recognition. He developed a new process to clean up pearls that had turned yellow. When the great Indian chemist Acharya Prafulla Chandra Ray heard the news of Gajjar's astonishing achievement he congratulated him.

Professor Gajjar earned lakhs of rupees from this venture. He then set up the 'Alembic Chemical Works' in Vadodara with help from his student Srikoti Bhaskar. Bhaskar was then sent to Germany to gain specialized knowledge. Meanwhile, he read litterateur Govardhanram Tripathi's novel *Saraswatichandra*, and was impressed

by the plan of Kalyan village. He met this great Gujarati novelist in person and they became good friends. He started one such scheme near Andheri. There, he began developing the cottage industry and encouraged traditional art for the welfare of the people.

Gajjar then, had plenty of money. Due to wealth, many disputes took place within the family that reached the court. Though he won the case, he lost a lot of money and peace of mind. Meanwhile, his wife passed away. He started feeling lonely. After the death of his wife, he never felt happy and cheerful.

Then came the unexpected news of the death of his student, Srikoti Bhaskar. He spent his health and wealth to keep Alembic Chemical Works stable and sustained. Life became difficult and worries affected his health. He was a depressed and dejected man. Gradually, he became a victim of sleeplessness. He had become very lonely. This great scientist was really moved when he once had the opportunity to meet Mahatma Gandhi. Gandhi advised him to spend his remaining life peacefully and happily.

Gajjar was his own doctor, but could not sustain his lifeline. On July 16, 1920, this great soul departed for his heavenly abode. Thus, this great chemist from Gujarat, after spending his hard earned money for the welfare of the people and gifting the laboratory he set up to the National Medical College, took leave from this world. We pay our heartfelt tribute to this great scientist and worthy son of Gujarat.

5

Dr D N Wadia

Dr Darasha Nausherwan Wadia, the father of Indian Geology, was born on October 25, 1883, in Surat, Gujarat. His family was traditionally involved in shipbuilding. Wadia completed his primary schooling in Surat. As a child, drawing interested him. When he was 12, the family settled in Vadodara (Baroda). He continued his schooling there and went on to complete his graduate and post-graduate studies from Vadodara College. At graduate level his subjects included biology and geology.

It was a time when geology and geological survey had not yet developed in India. In India, geological survey was established in 1851. A post-graduate degree in geology was only offered at Kolkata (Calcutta) and Chennai (Madras) Universities. Through reading, Wadia had developed an interest in geology and through self-study and introspection, he moved forward in this direction. In 1906, when he was just 23, he joined Jammu's Mahatma Gandhi College (Prince of Wales College) as professor of geology. During vacations, in the snow-clad Himalayas, he carried out underground research on minerals, stones and fossils. Gradually, his interest, study and research in the subject increased. He wrote a book titled *Geological Science* for the benefit of students. When the book was published, his fame in this field spread all over the country.

In 1921, he resigned as professor of this college and joined the geological survey department of the Geological

Survey of India (GSI) at the age of 38 years. At the institute too, the Himalayan region remained the centre of his research.

In 1938, at the age of 55, Wadia resigned from the GSI department and went to Sri Lanka (Ceylon). It was a time when the British ruled India and Sri Lanka. The British government had appointed Dr Wadia as the head of the Sri Lankan geological survey department. There he completed the task assigned to him and after appropriately training his colleagues, he returned to India. On his return, he joined the central government as director of land survey department and later served as director of Bureau of Mines–Minerals and Ores.

After India's independence, Wadia set about the task of promoting science. In the Atomic Energy Commission set up under the leadership of Dr Homi Bhabha, he was made director of the department handling minerals. He was instrumental in holding the 22nd conference of the International Geological Congress in New Delhi, the first ever in India. Wadia presided over the function.

Wadia toured abroad and carried out important research work on the Central Asian desert regions. He also provided detailed information about its mineral wealth. His views about the birth of the desert regions received tremendous response from all over the world. According to him, one million years ago the Ice Age existed. At present, icy cold rivers at the North Pole and the snow-covered areas were the result of that age.

In his book, 'Geology of Nanga Parbat and Gilgit District', he has provided detailed information about the geological survey work he carried out in this area. Besides, in his book 'Structure of Himalayas', he has discussed elaborately the geological formation and internal edifice of the Himalayas. In his detailed research on the Himalayas, he studied the rocks on the 27,000 feet (about 8,000 metres) high Nanga Parbat and the pebbles

obtained from its snow-melted rivers and got ample know-how of the region. Thus, he was a tough and adventurous man. The geological survey he carried out in the Himalayas shows his strong determination and perseverance. Half a century later his life of learning was one that would put any youth to shame.

The entire stretch from Kashmir to Kanyakumari, Assam to Karachi and Baluchistan, including lakes and oceans was his area of study. This entire stretch of area was like an open book to him. Beyond textbooks he had gained knowledge through discovery and analysis. He was a storehouse of knowledge. He also delivered his knowledge at various seminars. Experts have accepted Wadia's views on the geological structure of areas like Poonch and Punjab, the rise and fall of the Himalayas. His information on the spread of the Himalayas from Assam to Kashmir and its range of peaks is indeed a revelation. According to him, the Hindu Kush, with its unique mountain range, has no relation to the Himalayas.

Among his many writings, *The Geology of India and Burma* is a reference volume that gives wonderful information. In Geological Survey Institute libraries around the world this volume occupies a revered place. This volume is taken into account to understand the geological set-up of India. Wadia was also a successful scientific authority on fossils. His important fossil discoveries include animals without bones, huge animals like elephants, besides skull pieces of Stygordon Ganesa. Today, the uranium enriched area in Bihar is very useful to the Atomic Energy Commission, thanks to the direction given by Wadia.

In 1957, he was elected the Fellow of the Royal Society of London. He was the first Indian geological scientist to receive this honour.

He was twice elected president of the Indian Science Congress. The prestigious Meghnad Saha Medal was

awarded to him by National Science Academy. Kolkata's Asiatic Society honoured him with the Bose Medal. The Indian government conferred on him the *Padma Bhushan*. On June 15, 1969, this great Indian scientist died at the age of 85. On 23 October, 1984, the Post and Telegraph Department of India issued a stamp in honour of Dr D N Wadia. We salute this valiant son and pride of Gujarat.

6

Srinivas Ramanujan

Srinivas Ramanujan, the great Indian scientist who gained name and fame as a mathematician, was born on December 22, 1887, in a small village named Erode, near Kumbakonam in Tanjore district of Tamil Nadu. His father Kuppuswamy Srinivas Iyengar belonged to a poor, conservative Brahmin family. He worked as a small-time clerk with a local businessman. His mother Komalatamma was courteous and religious. The family's poor economic condition made it difficult to raise even one child.

Eventually, Ramanujan was admitted to the local primary school. The most intelligent boy in the class, his mastery over mathematics was unmatched. He could do mental calculations very quickly. Ramanujan was a child prodigy. Sometimes his questions would even put his teacher in a difficult situation. After school hours when other children would be playing, he would be busy with his slate and chalk.

In November 1897, at the age of 10, he stood first in the primary school examination in the entire Tanjore district. This paved his way for a free education at the Kumbakonam High School. In high school too, he stood first in all the mathematics examinations and received many awards. This impressed his teachers.

In Ramanujan's neighbourhood lived a college boy. Ramanujan once asked him for his mathematics textbook. The boy gave the book but wondered why a school student needed a college book. Later, he was surprised to know that Ramanujan had solved all the sums in the book. Then onwards, whenever he faced difficulty in mathematics he would consult Ramanujan. Now, he also got other mathematics books for Ramanujan from college. By 13, Ramanujan had read a book on trigonometry from the library. He proved the unsolved theorems given in the book, in his notebook. When he was 15, he obtained a copy of George Shoobridge Carr's *Synopsis of Elementary Results in Pure and Applied Mathematics*, two volumes (1880–86). This collection of some 6,000 theorems aroused his genius. Having verified the results in Carr's book, Ramanujan went beyond it, developing his own theorems and ideas.

In 1903, at the age of 16 he appeared for the matriculation examination. He scored a first class in mathematics and was awarded scholarship. He joined the government college. Even in college he was engrossed in mathematics and ignored other subjects. As a result he scored full marks in mathematics and failed in the other subjects. His scholarship was discontinued. He appeared again for the examination only to fail. This greatly upset his father and he had to discontinue his college studies. Thus, in 1906 his formal education came to an end.

His father was worried about Ramanujan's obsession with mathematics. To make him aware of his

responsibilities he was married at the age of 22. His wife Janaki was aged nine then. Now Ramanujan started his quest for a job. Though unsuccessful initially, mathematics eventually proved to be of help to him. Since 1903, Ramanujan had started noting down mathematical work in his notebook. By 1910, he had filled two thick books with his mathematical research. He took these notebooks and approached P Ramaswamy Iyer, the founder of the Indian Mathematical Society. Ramaswamy was greatly impressed on seeing these books. He gave him a letter addressed to the professor of mathematics at the Presidency College in Chennai (Madras). To his good luck, the professor had earlier taught at his college. He immediately recognized Ramanujan and gave him a recommendation letter addressed to Rama Rao, the Collector of Nellore. Due to his personal interest in mathematics, the Collector ensured that Ramanujan got a job at the Accountant General's office in Chennai. Sometime later, he got a job as a clerk in the accounts department of the Chennai Port Trust. His monthly salary of Rs 30 improved his economic condition to some extent.

Whenever he got time from office he wrote research articles. These articles were published in the Indian Mathematical Society magazine. This made him famous in the mathematics circle of Chennai. Soon some professors and educationalists became aware of his work and brilliance. With their recommendation he was awarded from May 1, 1913, a monthly scholarship of Rs 75 from Chennai University to continue his research in mathematics. At this time he did not have any university degree. On the advice of well-wishers he decided to seek the guidance of some great mathematician. In those days, England was considered the centre of mathematics. Ramanujan sent his 120 theorems and formulae to renowned mathematician Prof Godfrey H. Hardy, a Fellow of the Trinity College of Cambridge University. After he

had gone through these notebooks received by post he talked about them to his colleague Prof Littlewood. They realized the brilliance of the author of these notebooks. Soon an exchange of letters began between Hardy and Ramanujan. Hardy made an arrangement for Ramanujan to visit England. In the meantime, Prof E H Neville from Cambridge University came on a visit to Chennai University. Hardy had asked him to meet Ramanujan and convince him to come to England. Local friends and well-wishers were ready to render all possible help to him to visit England.

With such combined efforts, Chennai University agreed to grant Ramanujan an annual scholarship of 250 pounds for two years. Hardy had taken the responsibility of Ramanujan's travel and stay in England. However, his parents objected to his decision. For a boy coming from an orthodox Vaishnavite family, crossing the seas did not have the religious sanction. Finally, after being convinced by his well-wishers, Ramanujan's parents allowed him to go abroad. He reached England on April 17, 1914. Thereafter, under the guidance of Hardy and Littlewood, Ramanujan undertook systematic study and research. Meanwhile, the World War I broke out. With Littlewood having to go to the battlefront, Hardy looked after him and guided him.

With the onset of winter, Ramanujan found it difficult to withstand the harsh cold of England. Since he was an orthodox Brahmin and strict vegetarian he cooked his own food. He felt lonely too. Hardy saw in him a brilliant mathematician. Only due to his care and concern was Ramanujan able to stay in England for five years. Hardy had become his true friend, guide and philosopher. Sometime later Hardy wrote a letter to Chennai University stating that Ramanujan was indeed a great Indian mathematician and he had never met such a genius. After receiving his letter of appreciation, Chennai University extended Ramanujan's scholarship from two years to five

years till March, 1919. Only a matriculate, Ramanujan was conferred the BA degree in 1916.

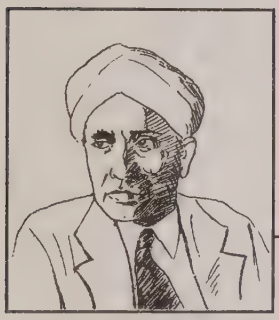
During his five years stay in England, 25 of his research papers were published. This had made him popular in the world of mathematics. Ramanujan was considered one of the greatest mathematician of that time. In October 1918, London's Royal Society made him a Fellow. He was the second Indian to receive this honour. Navy engineer Ardeshji Khordashji was the first Indian to receive such an honour in February 1918, by Trinity College.

In 1917, Ramanujan fell ill and was admitted in a hospital. Initially, the disease was diagnosed as TB, but later, it was believed to be due to lack of proper nutrition and deficiency of vitamins. Presuming that the dry weather of Chennai would suit him, the doctors advised him to return to India. Finally, in March, 1919, he returned to India. Despite being treated by friends and well-wishers, he met with an untimely death within a year on April 26, 1920 at Kumbakonam. A bright star set suddenly on the horizon. He was only 32 years old then. He was recognized by mathematicians as a phenomenal genius, without peer since Leonhard Euler (1707–83), Swiss mathematician and Karl Jacobi (1804–51), German mathematician.

His research in mathematics, which he noted down in three thick notebooks, is still known as 'Ramanujan's Notebooks'. Later, even these became a subject of deep study. In 1927, Cambridge University got these research works edited by Hardy and got them published. Still some of his research works remained unpublished. On the occasion of Ramanujan's birth centenary, the mathematics department of Tata Institute of Fundamental Research, Mumbai, got many of his works edited and published. One of his notebooks was found missing. It was Prof George Andrews who later found it. He is

conducting research in America and intends to get it edited and published.

In 1988, Cambridge University and Trinity College decided to grant a yearly pension of £ 2000 to Janaki Amma, the widow of this world famous mathematician. It was decided to grant this pension for his research work at the university, services he rendered to the institute and his research contribution to the world of mathematics.



7

Sir C V Raman

Chandrashekhara Venkata Raman, Indian scientist and the first winner of the Nobel Prize for Science in Asia, was born on November 7, 1888, in Tiruvanaikkaval village, Tiruchchirappalli district in Chennai (Madras), Tamil Nadu. His father Chandrashekhara Iyer graduated with physics and became a lecturer. Raman was the second child of his parents. Since childhood he was slightly built but excelled in studies. From a young age, he had won many prizes and scholarships.

At the age of 11, he passed the matriculation examination with first rank. Two years later, he cleared the university inter examination with a first class first, paving the way for his scholarship. He joined the famous Presidency College of Chennai for his graduation. Along with English, he had chosen physics as his principal subject. He was the youngest student in the college. Professor of English, Eliot was quite surprised to see

this young boy in class and was taken aback when informed that he was only a 13-year-old lad. In 1904, Raman passed Chennai University's BA examination from the Presidency College with a first class first in physics.

After completing his BA he was to be sent to England for further studies, but according to the civil surgeon of Chennai, his weak constitution would not allow Raman to withstand the harsh climate of England. Thus, his trip to England was cancelled and as an alternative he decided to study for MA with his favourite subject physics from the same college. The professor of physics at the Presidency College of that time was liberal with Raman. So, along with his studies he carried out experiments without any guidance. With the available equipment in the college he continued with his research work. Here, initially he carried out research on the diffraction of light. He submitted his research paper to his professor to read, but his busy schedule did not permit him to have a look at the paper for three months. Therefore, Raman worked on the paper again and sent it to London's Philosophical Magazine. This research work was published in November 1906. It was a unique achievement. Later, his second research work too was published in the same magazine. It was about surface tension in liquids. In 1907, he passed his MA in physics with a first class first and bagged all the medals and prizes.

Since ill health prevented him from going abroad, he decided to join the government service. He decided to appear for the Financial Civil Services examination; the country's best financial audit service. After appearing for the examination he confidently predicted he would stand first and it happened so. Meanwhile, he got married to Loksundari. At that time Kolkata (Calcutta) was the financial capital of India. He was appointed as the Deputy Accountant General there. He and his wife arrived in Kolkata. At such a young age, adapting a language and

culture different from theirs, his wife set up house in Kolkata and gave him all the cooperation he needed.

One day on his way to office Raman came across a board bearing the name 'Indian Association for Cultivation of Science'. While returning from office in the evening he visited the place and got all the information. He then came to know that the late Dr Mahendra Lal Sircar had set up this organization to popularize science among the masses. At first sight, Raman realized that no worthwhile activity was carried out in the organization. Raman subsequently got permission to carry out his experiments there. He was thrilled to get a facility to conduct experiments and carry out research at his own convenience and time. Now, he left early in the morning to engross himself in research there. He would then leave straight for office when it was time to go. In the evening, he would leave office to return there and continue his experiments and research till late in the night. Thus, his interest in research revived and began to bloom thereafter.

Here, he had to do all the work by himself. Ashubabu, the only servant of the organisation, would help him at times. Three decades after the organization was established, Raman's first research paper was published in the famous magazine 'Proceedings of Royal Society', London. Meanwhile, on the basis of his research papers he was awarded the Woodburn Research Medal. This was the first honour he received from outside the country. It meant that scientists outside the country too, had taken note of his research work. This way the 'Indian Association for Cultivation of Science' too received recognition from abroad. The chemistry and biology departments of the institute had also started functioning. Raman also started a quarterly magazine of the organisation. This research activity was besides fulfilling the duties as the seniormost officer of the finance department. In 1916, England's science magazine 'Nature' praised this institute and

Raman's research work in a detailed article. Now, this institute, three decades after it was set up had become well-organised and equipped. Raman had totally dedicated himself to the science and research work here.

Meanwhile, the Chancellor of Kolkata University, Justice Sir Ashutosh Mukherjee invited C V Raman to join the university as professor of physics. At that time Raman drew a salary of Rs 1,100 in government service. This would be reduced to Rs 600 if he joined the university. Raman accepted the offer to teach science out of sheer love for research.

In 1917, Raman resigned from the finance department and joined as professor of physics at Kolkata University. Now he would be at the association in the morning and evening and in the afternoon be involved in development of the physics department and research at the university. With Raman's efforts on two fronts, the university undergraduate department and the association made considerable progress. In 1919 with the death of Amrut Lal Sircar, the honorary secretary of the association, Raman was elected as the new secretary. In 1921, Kolkata University honoured him with an honorary doctorate degree. Now he became Dr C V Raman. The same year he made his first foreign trip. He was selected to represent Kolkata University at the University Congress held at Oxford in England. Here, he had the opportunity to meet world famous scientists like Sir Ernest Rutherford, Sir J J Thomson and others and exchange ideas. Here, he also got the facility to conduct some experiments. His return trip to India became a historic one. During the Mediteranean sea voyage, the blue colour of the water baffled him. Change in the wavelength of light that occurs when a light beam is deflected by water molecules giving the sea blue colour. Similarly, when a beam of light traverses a dust-free, transparent sample of a chemical compound, a small fraction of the light emerges in directions other than that of the incident (incoming)

beam. Most of this scattered light is of unchanged wavelength. A small part, however, has wavelengths different from that of the incident light. His research on scattering of light led to the discovery of an effect known as the 'Raman Effect' for which he was awarded the Nobel Prize for Physics in 1930.

In 1922, impressed by Raman's stature, K R Ramanathan, after obtaining scholarship from the Chennai University came to Kolkata to join Raman in research work. During his one-year stay there, he published about ten research papers. On the basis of these research papers, the Chennai University awarded him the Doctorate of Science (DSc) degree. During Ramanathan's research work in Kolkata, he witnessed a phenomenon that puzzled him. Later, it was named 'feeble fluorescence'. The phenomenon that remained a mystery for long, later culminated in the world famous 'Raman Effect'. Ramanathan was the first student to get a PhD degree under Raman. He later joined the Physical Research Laboratory (PRL) in Ahmadabad as its first director. He settled in Ahmadabad and guided many research students. He contributed immensely in furthering the name of the laboratory. The author of this book undertook research and received doctorate under Ramanathan's guidance.

In 1924, at the age of 36, Raman was elected Fellow of the Royal Society of London. The same year he undertook his second foreign trip. This time he visited Europe, America and Canada. At the California Institute of Technology, he lectured for four months as visiting faculty. This was a unique honour. His work had now become more systematic and his approach to work had also improved. His research now focused on the scattering of light. He also came to understand the phenomenon of 'feeble fluorescence'. In February, 1928, he announced the discovery of the historic 'Raman Effect'.

When light falls on any object the incident light is partly absorbed, reflected or passed through the object.

It also scatters light at times. Due to this new discovery, there was a surge of curiosity at the Indian Association laboratory in Kolkata. Visitors from India and abroad, came to congratulate Raman, for his discovery of 'Raman Effect'. In 1930, the Nobel Prize for Physics was awarded to Raman for this discovery. The British government in the country honoured him with the title 'Sir'. It was the highest honour given to a scientist not only in India but also in Asia. He now came to be known as Sir C V Raman. Honours started pouring in from all quarters. He was now at the peak of his career.

Meanwhile, search for a new director for Bangalore's famous Indian Institute of Science was on. Usually foreign scientists were appointed to this post. When London was asked, Raman's name was suggested. In 1932, Raman left Kolkata to join Bangalore based Indian Institute of Science (IIS) as director. In 1938, he resigned from this post and continued to work only as professor of physics. Today, IIS is one of the leading institutes for higher learning and research.

On November 21, 1970, he passed away at his dwelling at the *Raman Research Institute*. The plants and trees that Raman himself had grown were now silent, probably in a state of shock. His last rites were performed there. A commemorative marble plaque there revives memories of this great Indian scientist. Raman is no more but the fragrance of his work and his personality remains.

During his lifetime, Raman conducted research on scattering of light, sound, colour, the physics of minerals, diamond and crystal, besides research on colour of flowers, vision, etc. Of his 465 publications, three were published from Chennai, 177 from Kolkata and the remaining from Bangalore. In 1988, the Indian Institute of Science brought out all the writings of Raman subject-wise in six volumes. We humbly bow before this great Indian scientist.

8

Prof K R Ramanathan

Professor K R Ramanathan, a scientist with broad outlook was born on February 28, 1893, in Kalpathi village in Palghat district of Kerala. His full name was Kalpathi Ramkrishnan Ramanathan. His mother's name was Subbhalakshmi. His father was a scholar in Sanskrit and the Vedas, besides having deep knowledge of astronomy.

When Ramanathan was 13 years old, his mother died. He then had to bear the responsibility of his four younger sisters and almost blind grandmother. He completed his primary and secondary education in his village. He was an intelligent boy, who maintained his first rank throughout his education. He then joined Victoria College at Palghat for his intermediate studies. Later, he joined the Presidency College in Chennai (Madras) to complete his graduation in physics, in 1914 and post-graduation in 1917.

Prof Stevenson, his examiner at the MA practical examination, was so impressed by Ramanathan's viva voce replies that after he cleared the examination, Stevenson got him a job as demonstrator at the physics department of the Maharaja College in Thiruvananthapuram (Trivandrum). He worked for seven years in this college. There was a small office of the state meteorological department in the college premises. He took up the responsibility of observation for the meteorological department. This fuelled his interest in meteorology and also gave him some experience. During this time he had

trekked the Nilgiri Mountains and weather observations were noted at different heights up to 1,800 metres. Moreover, he had gathered reports of rainfall in different parts of Thiruvananthapuram and written a research paper on it. In 1919, this research paper was published in one magazine.

Prof C V Raman's popularity and work impressed Ramanathan. They were in touch through correspondence. Raman invited Ramanathan to Kolkata (Calcutta) to do research under his guidance. Meanwhile, Ramanathan received a one-year scholarship from Chennai University to conduct research. He took leave from Thiruvananthapuram and headed straight for Kolkata to do research with Raman. He became the first research student of Raman.

When light rays hit minute particles they get scattered in all directions. This process is known as 'Scattering of Light'. Lord Rayleigh had then proposed that if these minute particles are small compared to the wavelength of light, then the scattering of light with the smallest wavelength is prominent. The atoms in the atmosphere are very small compared to the wavelength of light. Therefore, during the day, the Sun's visible blue-coloured light with the smallest wavelength scatters the most. This is the reason why blue-coloured light can be visible prominently from all directions. Therefore the sky appears blue in colour.

At sunrise and sunset, the sunrays travel longer distance through the atmosphere to reach the earth. Due to scattering, except the light with the maximum wavelength the rest is dispersed. Therefore, light with the maximum wavelength meaning red light reaches us. So the light over the horizon during the morning and evening appears red or orange. In space or in vacuum there is no atmosphere; hence, scattering of sunlight takes place. Therefore, the sky appears black when viewed from space.

Raman was conducting research on scattering of light in Kolkata at that time. Ramanathan too joined in this research. During this study they witnessed a unique new phenomenon termed as 'feeble fluorescence'. However, neither Raman nor he could come to any plausible conclusion. Later, this event led Raman to the world famous Raman effect. Thus, the discoverer of the Raman effect, C V Raman considered Ramanathan as his first lieutenant. Thereafter, Raman's second lieutenant Dr K S Krishnan took forward this work in Kolkata.

The discovery of Raman Effect was announced on February 28, 1928, in Kolkata. Prof Ramanathan's birthday also falls on the same day. The Government of India has declared February 28 as National Science Day.

During his one-year stay in Kolkata, Ramanathan published about 10 scientific research papers in the world's leading research magazines. For his thesis based on these published papers he was awarded the degree of Doctor of Science by Chennai University. Chennai University had awarded the first DSc degree to Ramanathan. His one-year research scholarship was also over. To fulfil his household responsibilities it was necessary for him to take up a good job. In the meantime, he got an invitation from Myanmar's (Burma's) Rangoon University to join as assistant lecturer in physics. After seeking advice of Raman, Ramanathan accepted the job and left for Rangoon with his wife Parvati in 1922. To remain in touch with research, Ramanathan would rush to Kolkata at every conceivable opportunity. He stayed in Rangoon, for two years. Meanwhile, he was invited by the Indian Meteorological Department to join as a first grade scientist. After consulting Prof C V Raman, he resigned from Rangoon University and joined the Meteorological Department at its head office in Shimla. Till retirement he was with this department. He worked at various places during his tenure. In the meantime, he was given

the main responsibility of setting up the geomagnetic laboratory at Colaba, Mumbai (Bombay) and at Alibaug. From Shimla, he came down to Mumbai. He was then transferred to Agra. Here, using rubber balloons he recorded the high atmospheric temperature, humidity, air pressure and made a detailed study. In 1928, the head office of the Meteorological Department was shifted to Pune (Poona) from Shimla. Ramanathan was then transferred to Pune and given additional responsibilities, which he fulfilled efficiently.

During World War II, the Japanese army had reached Myanmar. At that time it was necessary to predict the exact weather conditions in the higher atmosphere for the safe flying of planes in Assam. Ramanathan was appointed as Superintending Weather Scientist and assigned the entire responsibility, which he fulfilled effectively. For his excellent services during the War, the British government honoured him with the title Diwan Bahadur. He never made use of this title. His contribution in the field of meteorology was noteworthy. His research of the ozone layer during his tenure in the department had brought him international fame. He had reached the position of Director-General in the Meteorological Department. He retired in February, 1948, at the age of 55.

Before retirement he had come in contact with Dr Vikram Sarabhai. Sarabhai wanted to set up a modern laboratory in Ahmadabad. He invited the mature and experienced scientist Dr Ramanathan to come to Ahmadabad after retirement and join the laboratory that was to be set up shortly as its director. Dr Ramanathan accepted the offer.

On March 1, 1948, two days after his retirement, Dr Ramanathan came down to Ahmadabad and took charge as Director of the Physical Research Laboratory (PRL). PRL was established in November, 1947. Initially,

the work began at Vikram Sarabhai's bungalow–'Retreat' in the Shahibaug area. In a few months the work was shifted to a few rooms in the M G Science Institute in the University area. In February, 1952, Raman laid the foundation of the new PRL building opposite, Ahmadabad Textile Industries Research Association (ATIRA). In April, 1954, India's first Prime Minister Jawaharlal Nehru formally inaugurated the new building. Gradually, the institute progressed. In 1966, Ramanathan relinquished the Director's post and continued his services as Professor Emeritus. He continued to guide in research and administration till his last days.

After joining PRL as Director, in 1948 he took a trip to Europe for the first time and visited the various laboratories there. He also attended the Eighth General meeting of the International Geology and Geophysics Society at Norway (Oslo). There he presented his research paper on ozone layer. At this conference he was elected Vice-president of the International Meteorological Society. Thereafter, he had to go often abroad to attend seminars, workshops and meetings. He was elected the President at the International Conference of the World Meteorological Society held at Belgium in 1951. Again in 1954 at its conference in Rome, Italy, he was elected President for three years.

The 18-month period from July 1957 to December 1958 was celebrated as the International Geophysical Year (IGY). Dr Ramanathan played an important role in this event. He was appointed Chairman of the Indian Committee. The headquarters of this society were located at PRL. In 1960, an honorary fellowship was awarded by Royal Meteorological Society, England to Ramanathan. He was the first Indian to get this honour. In 1961, the World Weather Organization honoured Ramanathan with the institute's medal. From 1961–67, he was appointed Chairman of the International Ozone Commission.

Four years after he came and settled in Ahmadabad, his wife Parvatiamma died. He regained his composure even during this difficult time. In 1966, the directorship was given to Sarabhai. Whenever it was necessary, Ramanathan would guide and advise him. Meanwhile, with the unexpected death of Dr Homi Bhabha, Chairman of India's Atomic Energy Commission in a plane accident, the commission's charge was handed over to Dr Vikram Sarabhai. Sarabhai was already the Chairman of the Space Research Organisation, besides being the Director of PRL. He had to shoulder the responsibilities of three institutions. During such moments, Ramanathan calmly guided him. The sudden death of Sarabhai on December 30, 1971, deeply shocked Ramanathan. Yet again, he patiently carried on, showing no signs of breakdown.

Ramanathan always showed courage during difficult times. Honours and awards never flattered him. He remained stoic and till the end continued to work. The author of this article has had some memorable experiences with him. In the initial years of PRL (1950–54), under his guidance, the author worked as a research scholar and obtained his post-graduate degree. Again in the golden era of PRL, the author joined as a research scientist and got the opportunity to do research with Ramanathan. During this time he got many opportunities to know him from close quarters. Prof Ramanathan was a father figure to his students.

After his retirement, Ramanathan came and settled in Ahmadabad. The major part of his life–more than 35 years were spent here. His contribution to Gujarat and especially Ahmadabad, in the field of education and physics in particular, is invaluable.

The Government of India honoured Ramanathan with the *Padma Bhushan* in 1965 and the *Padma Vibhushan* in 1976. In 1977, the National Science Academy awarded him the *Aryabhatt Medal*. He had also chaired the Indian

Science Academy's prestigious *Raman Chair*. In 1985, at the ripe old age of 92, he died after a brief illness. Till his last breath he had taken keen interest in scientific activities. To keep alive his memory, in the centenary year of the late Prof Ramanathan, the newly built air-conditioned auditorium at PRL was named as the 'K R Ramanathan Auditorium'. Moreover, with an individual contribution by his son Dr Krishna Ramanathan and financial assistance from PRL, every year a leading scientist is invited to deliver the Prof Ramanathan Memorial Lecture.

9

Dr Meghnad Saha

Charismatic Dr Meghnad Saha (Dr M N Saha) was one of India's eminent scientists and distinguished science teachers. This internationally acclaimed scientist was born on October 6, 1893, in Seoatali village in Dhaka (Dacca) district of Bangladesh (Bengal). He was the fifth child of a large, but economically weak family. His father Jagannath Saha, had a small provision store in the village. The family had to make do with the limited resources. His mother Bhuvaneshwaridevi was a cultured and able housewife, who managed to run the household smoothly.

Since Meghnad Saha hailed from the lower caste, he had to face caste-related insults many a time. This had brought about certain bitterness in him. Steeped in nationalism, this leading scientist during his lifetime had to face many injustices. He was admitted to the only primary school in his village and in a short time, came to be recognized as a brilliant student. After his primary education, on his teacher's advice, his father admitted him to the middle school in nearby Sumulia village. The school was about seven miles from his house. So, he had to tread 14 miles every day. A solution was found soon. Impressed by his studiousness, a gentleman named Dr Anantkumar Das provided him boarding and lodging at his place. This had a positive bearing on his studies. Here too, Saha maintained his impression as a bright student and was especially clever in mathematics. He never forgot Dr Das who had provided him boarding and lodging.

In 1905, he appeared for the middle school examination and stood first not only in his school, but in the entire Dhaka district. This got him the government scholarship. Further education had become easier now. For higher studies he went to Dhaka and joined the Government secondary school. Taking into account his brilliance at school, he was exempted from paying his fees.

Meanwhile, the movement for the division of Bengal had begun. The people and students vehemently opposed the Partition of Bengal. In 1905, the Governor of Bengal, Sir Bumpfield was to visit his school. Swept by the patriotic fervour, 12-year-old Saha along with other students actively participated in the programme to boycott the Governor. This resulted in the discontinuation of scholarship to him and he had to leave the school. He joined a private school, which posed a lot of difficulties for him. In 1909, Saha appeared for the matriculation

examination of the Kolkata (Calcutta) University. He stood in the first grade in entire Bengal. He was the top scorer in mathematics. Besides, he had scored extremely well in English, Bengali and Sanskrit. For further studies, he joined the Dhaka College. Here, besides science subjects he also studied German language. This proved to be beneficial later, for it was a time when Germany was a leader in the field of science.

In 1911, he passed his intermediate examination from Dhaka College with a first class. He stood first in mathematics and chemistry, and overall he was third in rank. He then joined Kolkata's famed Presidency College. During this time his professors included Sir Jagadish Chandra Bose and Acharya Prafulla Chandra Ray. The intelligent Satyendra Nath Bose and P C Mahalanobis were his friends and classmates. In 1913, Saha completed his graduation from Kolkata University with a first class and second rank. Thereafter in 1915, he cleared his post-graduation in mathematics with a first class and second rank.

To shoulder the financial responsibilities of his family, Saha decided to take up a job. He decided to appear for the Indian Financial Service examination. But it was not destined. He was accused of having ties with revolutionaries and hence, was not allowed to appear for the examination. Lack of any good job forced him to take private tuitions and earn his livelihood.

One year passed this way. Meanwhile, Vice Chancellor of Kolkata University, Sir Ashutosh Mukherjee, appointed Meghnad Saha and his batch-mate and first ranker Satyendra Nath Bose as lecturers in the mathematics department of the university science college. As Saha was outspoken by nature, he could not get along with the mathematics professor. As a solution, Mukherjee transferred Saha and Bose to the physics department. Soon in 1917, C V Raman joined the department as professor of physics.

During research in physics some problems relating to astrophysics cropped up. As a solution, Saha wrote a research paper titled *Theory of Thermal Ionization*. With his formulae, astronomers could get information regarding physical properties like heat and pressure of planets. At the age of just 25 years he had made such an important research.

Meanwhile, Einstein's *Theory of Relativity* was included in the post-graduate curriculum of physics. To make the new course material easier for the students, he along with Satyendra Nath Bose began translating many of Einstein's famous research papers published in German into English. Later, Kolkata University published these translations in English in book form. This proved fruitful with Saha's research paper on 'Maxwell Stresses' being published in the famous Philosophical Magazine in 1917. This was a great achievement at such a young age of 25 years. On account of his researches, he was conferred the Doctor of Science (DSc) degree.

In 1919, Kolkata University awarded him the Premchand Raichand Scholarship and he also received the travel aid fellowship. He took a two year trip to Europe for further study. On getting an invitation to work with Prof Fowler, he researched with him for five months on spectroscopy and astronomy. From there he went to Berlin. Here, he got an opportunity to work with world famous scientists like Max Planck and Albert Einstein. In 1921, he returned to Kolkata. In appreciation of his research work, he was appointed professor of physics in the university. After serving here for two years he resigned in 1923, as he got a better opportunity to serve as professor and head of the department of physics, Allahabad University. Here he worked for 15 years. Giving only scant attention to practical physics, he diverted his attention to theoretical physics. His contribution to theoretical physics is unmatched in India. His students

and leading theoretical physicists, Dr D S Kothari and Dr R C Majumdar have developed an active group of theoretical physicists and students at Delhi University. The credit goes to Saha for his unstinted efforts.

He once again got an opportunity to join Kolkata University as professor of physics and returned in 1938. It was a good period for him. After coming to Kolkata he started taking an active interest in the Indian Association for Cultivation of Science. In 1944, he was elected as honorary secretary of the institute. In 1950, he became its president. Meanwhile, the institute was shifted from the Bow Bazaar Street premises to its present premises at Jadavpur. Saha played a major role in this shift.

Realizing the importance of nuclear physics, Saha established the Institute of Nuclear Physics in Kolkata. Later this institute was renamed and is now, popular as Dr Saha Institute of Nuclear Physics.

In 1927, Britain's Royal Society elected him as a Fellow and honoured him. The Astronomical Society of France elected him as lifetime honorary member. He received many invitations from abroad for lectures.

He occupied high positions at the Indian Science Congress, Science Academy besides various other institutes. He was also a member of the University Grants Commission in the period 1948–49. He was elected independent member from Kolkata in the country's first Parliament and put forward many worthy proposals. He made all efforts to develop science and technology. Because of his efforts the national almanac was developed. He played an important role in the calendar improvement committee and almanac improvement committee.

On February 13, 1956, he left Kolkata to take part in the budget session of Parliament in Delhi. On February 16, 1956, while taking important papers to Rashtrapati Bhavan, he collapsed on the way and died while serving the country.

10

Prof Satyendra Nath Bose

Satyendra Nath Bose (Prof S N Bose) was born on January 1, 1894. Right from his school days he displayed extraordinary temperament. He was fondly called Satyen among his friend circle.

His intelligence was visible from his primary school days. He was first in all subjects in his class. Being a brilliant student both at the primary and secondary level, his teachers too were taken in by his personality. One of his teachers in secondary school remarked that in his mathematics paper Satyen deserved 110 out of 100 marks. The reason was obvious. He had also answered correctly the optional questions. Besides, he had solved the problems in number of ways.

After completing his high school education, he joined Kolkata's (Calcutta's) Presidency College. Mathematics and Physics were his principal subjects. In 1913, he completed graduation from Kolkata University with a first class first. In college, Meghnad Saha, another acclaimed scientist was his classmate and friend. For their post-graduation, both friends joined the Kolkata University College of Science. In 1915, Bose completed post-graduation in Applied Mathematics with a first class first. At second place was his friend Saha. During their study they came into contact with a German scientist Brule. He had a variety of science books. But they were all in German language. Both friends became fluent in the German

language and made a deep study of these science books. This way they improved upon their knowledge of science.

In 1916, the Vice-Chancellor of Kolkata University, Sir Ashutosh Mukherjee appointed Bose and Saha as lecturers of mathematics in the University Science College.

In 1905, Einstein put forth his *Theory of Relativity.* Kolkata University became the first in India to include this theory in the post-graduate course. Along with Saha, Bose took up the task of translating Einstein's important research papers published in German for the benefit of the students. Later Kolkata University published this translated version of Bose in book form.

After serving for five years as lecturer at Kolkata University, in 1921 he left for Dhaka (Dacca) as Reader at the Dhaka University. He made some important research there. These research papers were published in various science magazines. This work came to be recognized as Bose Statistics in the science world. At present post-graduate students of physics study this subject.

Before this important paper was published he had sent the manuscript to Einstein, along with a personal letter. In the letter he had written, "I am sending this paper for your views and suggestions. I am very curious to know your views. If you find this paper worth publishing, please publish it in the famous German research journal *Zeitschrift fur physic.* I will be grateful to you. Just to remind you that sometime back there was a request from Kolkata University to translate your research paper written in German into English. After getting your permission I had translated that work. I have been reading your write-ups. You've been my guide and teacher."

Bose's research paper *Statistics of Photon* was translated into German by Einstein. Einstein then sent it to the editor of the magazine. Einstein had made a personal note that the paper presents a realistic picture

of the subject. Later it became an important part of physics all over the world.

In 1924, on the basis of his research work, Bose took study leave and went abroad. In Paris, he conducted research at Madame Curie's laboratory. From Paris, he went to Berlin and met Einstein. Bose's work on Planck's Law and the Hypothesis of light quanta was generalized by Einstein and is now known as Bose-Einstein statistics. During his Europe tour he also came in contact with Louis de Broglie and Max Born. He came to be recognized on the world science scene. After he went to Europe to study, a new post of Professor of physics was created at Dhaka University. Friends and colleagues had urged him to send an application for the post. But a doctorate degree was necessary for this post, which he did not possess. Friends advised him to get a certificate from Einstein if it was possible. Initially he was reluctant, but eventually told this matter to Einstein. Einstein found it strange. He said, "Are not your published research papers enough?" But how would Einstein know about India's condition? After completing his two years of study, Bose returned to India. He was then promoted as professor. Better late than never, his work was recognized. Some time after his promotion, Sir C V Raman's student K S Krishnan came over from Kolkata to join as Reader in his department at Dhaka University. He was the same Krishnan who became the first director of the National Physical Laboratory in New Delhi, which was set up after Independence.

Once again Bose got an opportunity to return to Kolkata. He was appointed as professor of physics at Kolkata University. He stayed there till his retirement in 1956.

After his retirement, in 1958, he was elected as Fellow of the Royal Society of London. It was a late honour bestowed on him. It is said that in 1955–56,

when Prof Dirac visited India, he met Bose in Kolkata. He was quite surprised to know that Bose was not a Fellow of the Royal Society. It is believed that Dirac was instrumental in getting Bose elected as Fellow of the Royal Society.

Two years after retirement, that is till 1958, Bose was Member of the Rajya Sabha. Besides, he was also Chancellor of Vishwa Bharati University, Kolkata. Later, the Government of India appointed him as national professor.

Presently, two kinds of statistics are used to study the behaviour of particles; the particles which follow Bose statistics are known as 'boson' and the particles which follow Fermi statistics are known as 'fermions'. Boson is a subatomic particle with integral spin (i.e. with angular momentum in quantum-mechanical units of 0, 1, etc.) that is governed by the Bose-Einstein statistics. Bosons include mesons (e.g. pions and kaons), nuclei of even mass number (e.g. helium-4) and the particles required to embody the fields of quantum field theory (e.g. photons and gluons). Bosons differ significantly from a group of subatomic particles known as fermions in that there is no limit to the number that can occupy the same quantum state. This behaviour gives rise, for example, to the remarkable properties of helium-4 when it is cooled to become a superfluid.

Bose was a great theoretical scientist. Besides physics, he had knowledge of mineralogy, archaeology, philosophy and chemistry. In 1944, Bose was chosen as president of the Indian Science Congress. In 1954, the Government of India conferred on him the *Padma Vibhushan*. Bose had an unflinching love towards science, but he also loved literature. He enjoyed writing and reading poems. He had translated poems from French, Hebrew besides other languages into Bengali. He believed strongly that unless science, is translated into our mother tongue, its spread

is not possible. He made all attempts in this direction. He had started a magazine in Bengali named 'Know your Science'.

This great Indian mathematician and physicist died on February 4, 1974, at the ripe old age of 80. He would be always remembered for his work with Einstein in quantum statistics.

11

Dr Shantiswaroop Bhatnagar

Dr Shantiswaroop Bhatnagar was born on February 21, 1894, in Behda village of Shahpur district in Punjab. This region is now in Pakistan. When Shantiswaroop was just eight months old, his father passed away. His mother took young Shanti to her father's place in Sikandrabad in Uttar Pradesh. Here the child grew up in a cultured environment. His maternal grandfather was an engineer. Influenced by his grandfather, Shantiswaroop developed a liking for architecture and *vastu shastra*. Besides, chemistry and physics were his favourite subjects.

Lala Raghunath of Lahore was his father's close friend. He was the principal of Dayal High School in Lahore. He brought the young Shantiswaroop to Lahore and admitted him to Dayal High School. Lack of fatherly care since childhood, had instilled in Shantiswaroop, a sense of responsibility, seriousness and studiousness. This helped him in his studies. He became self-reliant and hard working.

In 1911, he passed his matriculation examination and joined Dayal College. At that time he came into contact with the famous Indian scientist Jagadish Chandra Bose and his interest towards science became a passion. After graduation, he joined the Christian College in Lahore for his post-graduation. Meanwhile, in 1915, he married Lajwanti. It was the time of World War I, but India was not directly affected, hence his studies continued unaffected.

Passing his graduate and post-graduate examinations with good marks ensured that he could study further at London University. There he began research under the guidance of physical chemistry Prof Donan. His area of study was the physical and chemical problems of emulsions. He wrote a dissertation on this subject and got the Doctor of Science degree. For further studies he went to Germany and did research for some time at the Kaiser Wilhelm Institute. He then left for France for a year. He did research at the world famous Sorbonne University in Paris and in 1923 returned to India.

After his return to India, on an invitation from Pandit Madan Mohan Malaviya, the founder of Benaras Hindu University, Varanasi, he joined the university as professor of chemistry. After a year, in 1924, he joined the Punjab University in Lahore as professor. He served here for long. Meanwhile, near Rawalpindi, a British company was involved in drilling of oil fields. Drilling work suddenly came to a standstill one day. With drilling equipment, engineers and workers becoming idle, a lot of overheads (expenditure) started piling up. It so happened that the place where drilling was carried out was a wet wasteland. Pools and puddles were once part of the area. The water there was salty. When the water dried up, the ground became hard as stone. On drilling such a ground, there was a gush of soil mixture, which got mixed with the salty water and slowly turned hard and dried up,

resulting in the drill coming to a standstill. This resulted in losses amounting to thousands of rupees daily. To come out of this impasse, the company tried every possible means: inquiring with people, giving open invitation through newspapers, besides luring people with huge rewards and payment to find a solution. Finally, someone suggested Bhatnagar's name. He took up the challenge to find a solution.

Bhatnagar had done a lot of research on emulsions like the mixtures of oil and water and various oily substances termed as colloids. Milk can be termed as an example of this type of emulsion and gum as an example of colloids. Bhatnagar visited the place and after taking samples from there, started work in his laboratory. He at once came to realize that this situation arose when the mixture coming out during drilling mixed with the salty water. It was not possible to stop the mixture from mixing with the salty water, but if the salt content could be done away with, then there was a possibility of solving the problem. He suggested adding a country gum to the mixture that gushed out during drilling. The gum would make the mixture sticky and stop it from turning hard. The ploy was successful. The company officials were ecstatic. The company had been saved from losing lakhs of rupees. The company gave Bhatnagar one and a half lakh rupees as prize money and an offer to share a suitable amount from the production profit. But this Indian scientist had fulfilled this mission as a duty towards his country. He refused to accept the reward. "I have just done my duty," he said.

Bhatnagar suggested the money be given to the Punjab University, to start a new department relating to petroleum research. Bhatnagar's decision to give away the prize money was appreciated by people. He was a true researcher and science teacher.

He served for 16 years at Punjab University. During this time, he did research on important topics like photochemistry, magneto-chemistry, etc. With help from a co-worker he had designed the Magneto Interference Balance, an instrument to measure the magnetism of various objects. Besides, he had perfected methods to develop colourless and odourless wax, kerosene which can give a brighter light, high quality lubricant oil, etc.

The British government then had set up a board for scientific and industrial research. Bhatnagar was chosen as its director. During World War II, he had developed a cloth and varnish that could be used for protection against poisonous gas. Besides, he had also developed a bubbly frothy mixture to extinguish fire.

In 1947, when India attained independence, the first Prime Minister Jawaharlal Nehru gave priority to projects that encouraged science. Bhatnagar provided the necessary inputs and guidance. After independence, the Scientific and Industrial Research Department was rechristened as Council of Scientific and Industrial Research. Under Bhatnagar's guidance 12 high class and well-equipped national laboratories were set up, to provide all the facilities to the country's budding scientists.

Bhatnagar had taken up the responsibility of various organizations : as director of Council of Scientific and Industrial Research (CSIR), secretary to the Government of India's Scientific Research Department, secretary to Atomic Energy Commission, University Grants Commission chairman, etc. He contributed immensely by attracting financial aid for scientific research and developing facilities for them.

Many universities and research institutes in the country and abroad bestowed on him honorary doctorate degrees and honorary membership. Britain's Royal Society made him an honorary member in 1943. The Government of India honoured him with the *Padma Vibhushan*.

On January 1, 1955, at the age of 61, this great sage and scientist died. The Dr Shantiswaroop Bhatnagar Award is given every year for excellence in any field of engineering, science and technology. This is the country's biggest and the most prestigious award in the field of science.

12

Salim Ali

India's famed ornithologist Salim Ali, was born on November 12, 1896, in a big Muslim family of Khetwadi in Mumbai (Bombay). His full name was Salim Moinuddin Abdul Ali. He had five brothers and four sisters. His mother's name was Jijat-un-nissa. When he was a year old, his father passed away. At the age of three, his mother too passed away. His uncle Amiruddin Taiyabji aroused in him a curiosity towards birds. After the death of his parents, uncle Amiruddin and aunt Begum Hamida raised all the children.

It was a time when interest in birds was minimal. Birds were sold freely in Mumbai's markets. For one rupee you could get eight to twelve birds many a time.

Ali would bring such a variety of birds, keep them in cane baskets, teach them a little and then release them. He would never confine any bird for long or keep a pet forever. He would catch a bird, study it and after noting down its traits, release it.

At the age of eight he was admitted to a local school. In a short time he got admission to the St Xavier's School. At the age of 14 years, owing to poor health he had to go and live with his brother and sister-in-law in Hyderabad (Sindh, Pakistan). There too along with the office peon he would look out for bird nests and study the birds and their eggs. In 1913, at the age of 17 years, he passed the matriculation examination of Mumbai University. By this time he had read books on hunting, wild animals and jungles and gathered some interesting information. Such readings and introspection led Ali to a liking for wildlife. He would catch birds and make a comparative study. Then life suddenly took a turn. A letter from a relative in Myanmar (Burma) arrived. It mentioned that if Ali was not interested in studies he could come and join the newly set up mining industry in Myanmar. Salim was finding mathematics a difficult subject, so he at once agreed to leave for Myanmar. Though he was never interested in business, he was very keen to know the wildlife in the jungles there.

Here, he met a forest officer J C Hoywood. Ali learnt a lot about Myanmar's birds from Hoywood. He gathered a lot of knowledge about birds and the scientific study of birds (Ornithology). Not inclined towards business, he had to return to Mumbai. Here he came in contact with Father Blater, head of the biology department of St Xavier's College. With his encouragement, Ali completed his graduation with animal science as his subject. In his 22nd year, in December 1918, Ali married Tehmina, who was well-versed in English and Urdu and had a visa for England. Tehmina encouraged her husband in his study of birds.

He had no post-graduate degree in bird science or biology, but in five to seven years after marriage he had gathered a lot of information and gained insight into bird science, biology and animal science. In the meantime, he got a job in a friend's export unit. Some time later,

Father Blater came to his rescue. He got him a job as guide lecturer at Mumbai's Natural History Society Museum. After joining here he realized that if he wanted to become an authority on birds he had to make their systematic study. No such course on bird science was offered in any institute anywhere in the country. So, he decided to go to Berlin for such a study. There he started the study of birds with Bernhard, a young bird scientist. In Berlin, Ali studied with dedication and single-mindedness. In 1930, he returned from Berlin and started work in Nizam's Hyderabad. He also received some grant for this. He studied bird science and also made a survey of birds. His study of bird habits earned him praise. Here he got a good opportunity to study the birds of Nilgiri.

Between 1934 and 1939, Ali studied bird science in Dehradun. Now, he came to be recognized among the world's well-known bird scientists (ornithologists). In 1945, he made a scientific study of the birds of Kailas and Mansarovar. He has mentioned the details in his autobiography–*The Fall of a Sparrow*. In the deserts of Kachchh, he undertook a study, which he brought out in a volume titled *Birds of Kachchh*. For the study of birds he also undertook a motorcycle tour of Europe. His diary reveals many such instances.

Now, he was an internationally known ornithologist. His work came to be appreciated in the country and abroad. He received honour and awards. In 1953, he was awarded the Asiatic Society Medal and in 1981, the Asiatic Society of Bangladesh as an appreciation of his work awarded him the Gold medal. In 1958, the Aligarh Muslim University; in 1973, the Delhi University and in 1978, the Andhra University honoured him with Doctor of Science degrees. The Government of India honoured him with *Padma Bhushan* in 1958 and the *Padma Vibhushan* in 1976. Besides, in 1982, the Government of

India honoured him by giving him the national research professorship in bird science. He was lauded for his efforts to protect wildlife and was awarded the National Award (gold medal) in 1983. The same year America's National Wildlife Federation honoured him with the International Award. On June 20, 1987, this great ornithologist left this world.

13

Dr J J Chinoy

The towering figure of modern botany, India's great scientist and Gujarat's famous son Jamshedji Jijabhai Chinoy was born on February 18, 1909 in Kachchh-Bhuj. He had his college education in Mumbai (Bombay). In 1929, he cleared BSc in Botany with a first class (distinction) from Mumbai University. After losing his father at a very young age, he was brought up by his grandfather. Some years later, his grandfather too, passed away. With courage and hard work he surged forward. Considered a bright student in school and college, he regularly took part in various debates.

Having stood first at the graduate level in his subject, he was awarded the Dakshina Fellowship by Mumbai's Government College, better known as Royal Institute of Science at that time. Besides, he received Mumbai University's Research Fellowship. In 1931, he cleared MSc with first class honours. Because of his promising career and good results; after he completed post-

graduation, he went to Britain on a Research Fellowship. To do PhD from London University, he joined the Imperial College. There he had the unique opportunity to undertake research under the guidance of world-renowned botanist Professor F G Gregory. In 1935, he was awarded the PhD degree by London University.

After completing PhD, he returned to India and joined the Central Cotton Committee at Layalpur as physiological assistant. In 1941, he joined the Indian Agriculture Research Institute as Assistant Economical Botanist. When India attained independence, more doors opened for brilliant research scientists. Meanwhile, this brilliant research scientist was invited to join as Reader at the botany department of Delhi University. He accepted it wholeheartedly. Thus, he became associated with university education. He taught for 22 years at the post-graduate level and was engaged in research. Many of his research papers were published during this time. He also actively participated in many research workshops and seminars abroad.

In 1959, when he got the opportunity to join Gujarat University, he snapped it to serve his native place. He joined as professor and head of the botany department. Meanwhile, from 1962 to 1974, he was also the director of the University School of Sciences.

For the last 50 years he was engaged in pure and applied research. His research work received recognition from various institutes and the science world. In 1959, at the ninth International Botany Congress held at Montreal in Canada, he headed the plant physiology section. In 1961 for his outstanding research, Gujarat University awarded him the Dr K G Naik gold medal. In 1964, he was specially invited to represent India and take active part in the discussions at the tenth International Botany Congress in Edinborough. In 1975, he was selected as the working vice-president of the

twelfth International Botany Congress held at Leningrad in Russia. At this congress he was awarded a special medal for his exceptional research work.

Besides, Chinoy also visited the world-famous biological research schools in England, Holland, France, Germany, Belgium, Sweden, Norway and Russia. In many of these countries he honoured the invitation extended to him by the science academies to lecture in their lecture series.

He was appointed Fellow of Indian Academy of Science. Besides, there was a demand for his lectures at the botany seminars held at Bhavnagar, Vadodara (Baroda), Kolkata (Calcutta) and other places in India. In these seminars he was invited as president, vice-president or chief speaker. Wherever possible he would go, there would be exchange of thoughts and others would be benefited by his knowledge. He was the patron member of the Plant Physiology Society of India, besides serving as honorary secretary, vice-president and president.

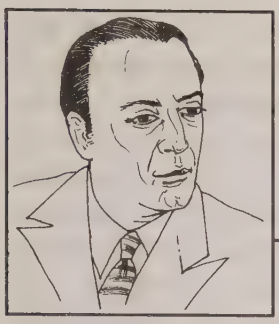
The prestigious Rafi Ahmed Kidwai Memorial Prize awarded every year by the New Delhi based Indian Council for Agriculture Research, was awarded to Chinoy for 1974–75, for his agricultural botanical research.

Chinoy had developed a plant strain with disease-free and fast growing seeds besides seeds that required less water and could be grown during droughts. He contributed immensely towards cellular and molecular biology. More than 250 research papers of his were published in national and international magazines. Under his leadership a group of leading scientists was working on plant physiology at Gujarat University. This group received recognition in India and abroad. Under his able guidance more than 100 students got their PhD degrees. These students are holding high posts in well-known research institutes within the country and abroad. Till

his last breath, Chinoy rendered service in this field. Even after retirement he continued his honorary services. Under the aegis of the University Grants Commission, New Delhi, Chinoy conceived the book 'Role of Ascorbic Acid in Plant Metabolism'. This great scientist who believed in the adage 'Work is Worship' remained active till the end of his life.

Chinoy was an optimist and mild-mannered. Nobody ever found him furious. Punctuality and discipline were his watchwords. He cared for his students, employees and co-workers. He understood their personal problems and always tried to help them. He believed that if there is no teamwork there could be no worthwhile research even though the laboratory is well-equipped. With a smiling face he would enter the department on time and the entire department would liven up. It was said that he had a sweet tooth. His voice and speech too, were melodious and sweet-sounding.

On March 12, 1978, at the age of 69 years, the country's great scientist Chinoy took leave from us forever. He has departed mortally, but left a body of sincere students behind. We will always remember this honest son of the soil and scholar of Gujarat through his works.



14

Dr Homi Bhabha

The father of Indian atomic energy and a great scientist, Dr Homi Bhabha was born on October 30, 1909 in Mumbai (Bombay). His full name was Homi Jehangirji Bhabha. His grandfather Horamsji Bhabha was the inspector general in the Education department of Mysore State. Homi Bhabha's father Jehangir H Bhabha was an Oxford graduate and a leading barrister. He practised law in Mumbai and was the legal adviser to the Tata group. Besides, he represented the Tata family as the council member of the Indian Institute of Science, Bangalore. Homi's mother Mehraben was the daughter of Mumbai's leading industrialist and citizen, Sir Dinshaw Petit. She was a beautiful, smart and cultured lady.

Homi, in his childhood, hardly slept. It was but natural, a cause for concern for his parents. They decided to get him checked by some specialist doctor. Since they did not come across any specialist doctor here in India, they took him to London. The doctors checked the child and declared him perfectly fit. The reason for his lack of sleep was his hyperactive mind. He will grow up to be a very intelligent man, they said. The parents were happy and returned home.

At that time rich, educated Parsi families followed the English lifestyle. Homi's family too had that high status. They admitted Homi to Mumbai's Cathedral School. All the teachers of this school were British and many students were from English families. The whole

atmosphere resembled a 'mini England'. He excelled in his studies and won several scholarships and awards at school. Besides studies, he was interested in poetry, music and painting. Since childhood he used to make good copies of original paintings. He made beautiful landscape paintings and self-portraits. At a painting exhibition he even won a prize. Many of his paintings are still displayed at London's art gallery. Science and mathematics were his favourite subjects. He made good use of his school library. He also had a good library at home. In class he was always ahead of the other students.

At the age of 16, he cleared the senior Cambridge examination and got admission in Mumbai's Elphinstone College. His father and other family members wished that Homi should obtain an engineering degree from England and join the Tata Steel Company at Jamshedpur. He joined the engineering study in England, but his interest lay in mathematics and physics. He wrote a letter to his father and asked permission to pursue further studies in physics. The wise father put him a bet. If he came first in the engineering examination he could stay in England for two more years to study his favourite subject.

The obedient son took up his father's challenge. He concentrated on his engineering education and stood first at the examination. He first graduated as an engineer. His father was pleased and as promised he arranged for his son to continue with the study of his favourite subject for two years.

Homi was encouraged further. He took up theoretical physics for his study. Now he spent a lot of time at the Cavendish Laboratory. He also excelled in his study. In 1932, he received the Rouse Ball scholarship for the study of mathematics. In 1933, he was selected for the Isaac Newton scholarship. At that time an informal group, Kapitza club used to run in England. The members of this club used to meet every Tuesday evening for a

discussion on matters related to physics. Besides, these members were interested in drama and athletics. Bhabha got the opportunity to join this club. During his stay here, he was deeply involved in the study of cosmic rays and fundamental particles. His first research paper was published in 1933. While studying there, he also visited various important educational institutes in Europe. In Copenhagen, he met scientist Niels Bohr, in Zurich Prof Wolfgang Pauli and in Rome Enrico Fermi. At Cambridge, he developed a strong relationship with Sir John Douglas Cockcroft and Gilbert Newton Lewis. These relations came in handy in fulfilling his dreams after he returned to India.

The 30's decade (1930–39) was an important period in the field of physics. Many new discoveries were announced during this period. The spotlight of scientists was focused on atomic energy. How could atomic energy be produced? Where and how could it be used? At this time Bhabha had shed light on the nature of cosmic rays. He had gained insight into the meson sub-particles in the cosmic rays. He had put forth important information regarding the principles of 'Cascade Theory'. Homi Bhabha's knowledge too flowered during this period.

In 1934, he took PhD degree from Cambridge University. Thereafter till 1939, he was at Cambridge. During this time he had the opportunity to conduct research and exchange ideas with many world-famous scientists. Dr Homi Bhabha came to be recognized as a brilliant scientist among world scientists. In 1937, he received another scholarship. The same year he received the 'Adam Pright' prize for his research publication.

In 1939, he returned to India to spend his holidays. During this period, World War II broke out in Europe. Many of his colleagues at Cavendish Laboratory were assigned war duty. He now found India to be the most suitable place for research in science. Meanwhile, Professor

Sir C V Raman invited Bhabha to join the Indian Institute of Science at Bangalore as faculty member, which he accepted. He joined as Reader in physics.

Dr Homi Bhabha brought here new physics from Europe. His joining added to Raman's enthusiasm. Here, he got the opportunity to conduct experiments in cosmic rays. Vikram Sarabhai too, had joined here at that time for his research on cosmic rays. It was a combination of two great scientists. Within two years, at the recommendation of C V Raman, Dr Homi Bhabha was conferred the fellowship of the Royal Society. This was a big honour for him. Meanwhile, Allahabad University and Kolkata (Calcutta) association invited him for professorship. But he accepted the professorship at Bangalore and chose to stay there.

Bhabha explained the importance of fundamental research in pure and applied physics to the Tata Trust and in 1945, set up the Tata Institute of Fundamental Research (TIFR) in Mumbai. Bhabha handled the entire responsibility of the institute. After India attained independence, the then Prime Minister Jawaharlal Nehru called a meeting of the top scientists in the country. He set up Indian Atomic Energy Commission and Bhabha was made its chairman. Besides, the central government started a department dealing in atomic energy. As secretary, Dr Bhabha was entrusted the responsibility. Thus, he became a bridge between science, scientists and the government. He emerged as an intellectual researcher and able administrator.

In 1954, an 'Atomic Research Centre' was set up at Trombay, near Mumbai. Today this centre is known the world over as the 'Bhabha Atomic Research Centre' (BARC). At this centre research is carried out in molecular biology, radio astronomy, electronics and other fields.

Tata Institute is now involved in fundamental research as the country's premier research institute at its huge

complex in Colaba. In 1963, Dr Bhabha's dream was fulfilled. India's first atomic power station was set up at Tarapur in Maharashtra. Now, there are about eight such stations in the country. In Gujarat at Kakrapar, an atomic power station with two such units is operating.

In 1956, under Bhabha's guidance India's first atomic reactor 'Apsara' was commissioned at Trombay, near Mumbai. Thereafter, two such reactors–'Cirus' and 'Zerlina' were also made functional. In 1955, an atomic fuel thorium plant was set up. In 1959, 'Nuclear Metal Plant' was also commissioned, which produces around 30 tons of nuclear grade uranium every year. In 1962, a Heavy Water plant was started. Today, there are around 10 such plants in the country including the one in Vadodara (Baroda) that fulfil the country's requirements.

In 1955, the United Nations organized the first international conference on the use of atomic energy for peaceful purposes. Bhabha was appointed as the president. Here, he advocated the message of peace. He called for a ban on the destructive use of atomic energy and advocated its peaceful use.

In 1944, Patna University, in 1949, Lucknow University and in 1950, Banaras University conferred on him honorary doctorate degrees. Thereafter, many Indian and foreign universities conferred on him honorary degrees and glorified him. In 1951, he was elected as the head of the Indian Science Committee. In 1954, he was awarded the *Padma Vibhushan*. In 1961, he was honoured with the Dr Meghnad Saha gold medal. In 1964, he was presented with the Mąlchet Award.

This father-like figure of the Indian atomic age was a polite man. He remained unmarried. When someone asked him about marriage, he said, "My love is focused on creating something new." His leisure hours were spent in listening music or painting. He strongly believed that the destructive use of the atom should be banned and its peaceful use should be encouraged.

The science related organizations of the United Nations are situated at Geneva in Switzerland. Whenever he had to go there, the flight would invariably pass over the Alps mountain range. He was impressed by the beauty of the Alps and never failed to describe them. On January 24, 1966, the plane carrying him and other passengers exploded in mid-air over the Alps and Bhabha was buried in the snows of the Alps. For any accomplishment the country has achieved in the field of atomic energy, the credit goes to Dr Homi Bhabha. At the age of just 57, we lost our great scientist unexpectedly.

15

Dr S Chandrashekhar

By birth an Indian, but one who later settled in America, Dr Subrahmanyan Chandrashekhar, was born on October 19, 1910 in Lahore. He was the nephew of Nobel laureate Sir C V Raman.

Chandrashekhar did his schooling, college and post-graduation from Chennai (Madras). Since childhood, he was an extraordinarily brilliant student. He was deeply interested in mathematics. In every class, he stood first. Apart from studies, he was also interested in reading and knowing about science.

He completed his graduation (BA honours) from the Presidency College, Chennai with physics. He was a voracious reader during his college days and the university

library provided him the necessary books. After completing his BA at the age of 18, he wrote his first research paper, which was published in the *Indian Journal of Physics*. Thereafter during his post-graduation many of his research papers were published which included one published in the Royal Society of London, a rare honour then. In 1930, at the age of 20, he cleared his post-graduation with a 'first class first' from Chennai University.

After his MA degree from Chennai University, on getting a scholarship for further studies from the Government of India, he went to England in 1930 and began research work at Trinity College, Cambridge. At Cambridge University, he studied under Dirac. During his study there, he gained respect from his teachers. On the basis of merit he was awarded the Sir Isaac Newton Scholarship. Later, he received the Trinity College Fellowship. He also gained recognition as an able astronomical scientist.

In 1936, he received his PhD degree from Cambridge University. The next year he left England for America. Here he joined as research associate at the Chicago University Observatory. Chandrashekhar came in contact with Ottostrev, a great astronomer and director of Yerking Observatory in Wisconsin. Here he undertook research for one year with him. Thereafter, he was invited to join as professor by Chicago University. He accepted the offer and served there as professor from 1938 to 1947.

Chandrasekhar's popularity as teacher and researcher soon began to spread. In 1944, the Royal Society of London elected Chandrashekhar as Fellow and honoured him. When he was professor at Chicago University he drove 160 kms every week to Yerking Observatory to lecture just two students Tsung–Dao Lee and Chen Ning Yang. Some people even wondered why Chandrashekhar took so much pain for just two students? Originally Chinese but, who later became American citizens, these

two were exceptional students. These two researchers were awarded the Nobel Prize for Physics in 1957. It is but natural for professors to enjoy teaching such bright students. It is great experience for any person to receive the Nobel Prize. The institution, its members and the entire country of the Nobel Prize winner feel proud. And more so for a teacher when his student is awarded the Nobel Prize.

From 1947 onwards Chandrashekhar was appointed professor of astrophysics at Chicago University. In 1952, he became editor of the Astrophysical journal. As a scientist he excelled in various fields. He explained with ease topics like the formation of stars, their life span and various other principles relating to them. His contribution in the research of plasma physics is also vital. In 1960, Chicago University arranged a lecture by Chandrashekhar on plasma physics.

Scientists had concluded by early 1930 that after converting all of their hydrogen to helium, stars lose energy and contract under the influence of their own gravity. These stars known as white dwarf stars contract to about the size of the earth and the electrons and nuclei of their constituent atoms are compressed to a state of extremely high density. The limit known as Chandrashekhar limit–was determined by him which meant that a star having a mass more than 1.44 times that of the Sun does not form a white dwarf but instead continues to collapse, blows off its gaseous envelope in a supernova explosion and becomes a neutron star. An even more massive star continues to collapse and becomes a black hole. Further, these calculations help to understand the state of supernovas, neutron stars and black holes. For his research and contribution in various fields, his

admirer and world famous astrophysicist Ottostrev has truly said, "Chandrashekhar is like the white ray of the sun, which has seven colours in it." Though he has contributed in various fields, Chandrashekhar called himself an astronomer.

Based on his research he has brought out four volumes. The Chicago University published two of these. Oxford University published the third volume. And the Royal Society of London awarded the Royal Medal to the fourth volume. In 1952, he was awarded the 'Bruss' gold medal. In 1957, he was awarded the Rumsford Medal by the Art and Science Academy of America.

In 1983, Chandrashekhar and William Fowler were jointly awarded the Nobel Prize in Physics for their principles on the birth and death (formation and disintegration) of stars. Dr Chandrashekhar was a world famous Indian astroscientist though he was an American citizen. In America too, his lifestyle resembled that of a music-loving Tamil Nadu Brahmin. He always wore a *lungi* at home. It is said that he worked for more than twelve hours a day for more than sixty years. In his leisure hours he would listen to Carnatic music. This great scientist died on August 21, 1995. Astronomers the world over will always remember him and his research work.

16

Dr Vikram Sarabhai

The pioneer of the Indian space research programme and the pride of Gujarat, Dr Vikram Sarabhai was the son of the famous industrialist Ambalal Sarabhai. He was born on August 12, 1919, in Ahmadabad. His father was a free thinker; an eminent and gutsy industrialist. His mother's name was Sarladevi. She was a bold and progressive social worker. In this happy, prosperous and cultured family along with Vikram, eight brothers and sisters were provided education at home in their family school. All the children studied here and were well-educated.

Since childhood, Vikram was creative and full of curiosity. He often questioned his teachers and tried to unravel nature. From the start he was interested in mathematics and science, especially physics. The atmosphere at home too was conducive. Great personalities and scholars visiting Ahmadabad would be his father's guests. Poet Laureate Rabindranath Tagore after talking with young Vikram had envisioned that this child would grow up to become a beacon of hope.

He spent his first two years of college at Gujarat College in Ahmadabad. After clearing his inter science examination from Mumbai (Bombay) University with distinction he left for England for further studies. He joined the St John College there and in 1939, he cleared the Tripos in physics. When he started research study the World War II had begun. He returned home to join Bangalore's Indian Institute of Science and under the

guidance of Professor C V Raman began research on cosmic rays. Meanwhile, Dr Homi Bhabha who too had returned from England, joined this institute. These two scientists forged a strong affinity.

Sarabhai knew that detailed study of the cosmic rays coming from the galaxy would help in understanding the magnetic field in space, the atmosphere, nature of the Sun and outer space. By the study of cosmic rays he was expected to unravel the mysteries of the solar system. To conduct experiments on cosmic rays, he went to the high ranges of the Himalayas. He found the high peaks of Kashmir best suited for the study of cosmic rays. After completing his experimental work on cosmic rays in India, he went to England once again in 1945. After obtaining PhD degree from Cambridge University, he returned to India.

While studying in Bangalore, he came in contact with the famous dancer Mrinalini and in 1942 they got married.

Sarabhai set up Physical Research Laboratory in his residential bungalow. Meanwhile, Dr K R Ramanathan, who had retired from the Indian Meteorological Department, was invited to join as the first director of the new institute. In a short time this laboratory was shifted to the M G Science Institute premises in the University area of Ahmadabad. Later the PRL started work in its own multi-storeyed building and is now famous in science circles in the country and abroad.

Quiet and soft-spoken Sarabhai believed in punctuality and hard work. He behaved courteously with his students and co-workers. In 1955, a branch of PRL was opened in Gulmarg, Kashmir. Here the study of cosmic rays was started. In 1963, the Government of India developed this institute as an independent laboratory. Today, it is known as 'High Altitude Research Laboratory'.

Sarabhai contributed immensely in setting up of and managing many high level research institutes. He was a visionary, who selected worthy students, trained them and gave them befitting responsibilities. In Ahmadabad, he set up many institutes. To help textile industries of this city, he set up Ahmadabad Textile Industry Research Association (ATIRA). To train able administrators, the Indian Institute of Management (IIM) was set up. For school students to perform and understand experiments on their own, the Community Science Centre (CSC) was set up in the University area (which after the death of Sarabhai was renamed the Vikram A Sarabhai Community Science Centre (VASCSC)) and many well-equipped institutes were set up for the development of space programmes. Besides, he set up PRL centres at Kodaikanal and Thiruvananthapuram (Trivandrum). In 1965, he took charge as director of PRL. He set up the rocket-launching centre at Thumba. Since this centre is situated near the magnetic equator and scientists from all over the world can conduct experiments from here, this centre was dedicated to the international scientists community. After sometime, a space science and technology centre was established nearby. This centre was renamed the 'Vikram Sarabhai Space Centre' (VSSC) in his honour and memory. Like a magician who rubbed his hands to produce bouquets one by one for the public, Sarabhai after setting up PRL, established various institutes for its development in the space sector. Today all have sprawned into giant trees. At Sriharikota, he set up another rocket launching centre and in Ahmadabad; he set up the Space Applications Centre (SAC). Under the SITE (Satellite Instructional Television Education Programme), educational TV programmes were relayed from here since 1975.

Sarabhai also looked after the industries set up by the family. He guided the students and after discussing space-related experiments with his co-workers would plan them. The Physical Research Laboratory was like the

cradle of the Indian space programme. Here its childhood prospered. He was also the active member of the Atomic Energy Commission set up by the Government of India under the chairmanship of Dr Homi Bhabha. In 1966, after the untimely death of Dr Bhabha in a plane accident, Sarabhai had to take over the reins of the Atomic Energy Commission. He fully discharged his duties and guided the country to take a giant leap. Meanwhile, he took full responsibility and discharged his duties as chairman of the Indian Space Research Organization (ISRO).

Vikram had made up his mind to make the country self-reliant in the field of science and technology. Those days he worked for 15 hours daily. His only mission was to see the country progress in science and technology. He had discussed with his colleagues how to use the new technology for the benefit of the country and prepared a plan for the 1970–80 decade. He had put particular emphasis on the use of space science for the benefit of the country.

He had gone to Thumba for some experiments regarding rockets and meetings in the end of December, 1971. He had attended meetings till midnight. Late in the night he worked for a while in his hotel room before he went to sleep. But he never got up in the morning. It was then that the world came to know of his death. In the early hours of December 30, 1971, he had died in his sleep due to a heart stroke. Thus, he departed from us when he was just 52 years old. He had worked till the last hours of his life. He was a true *karmayogi*.

In the 1960 decade, it was confirmed that an artificial satellite would be very useful for the study of the world's weather forecast. It was also clear that the satellite technique would be useful in knowing and developing our mineral wealth, in remote sensing, communications, farming, education, weather and defence services. Because of Sarabhai's perception, the national committee for the

space research programme was set up under his leadership, which was later renamed the Indian Space Research Organisation (ISRO). Today this organization has progressed a lot and earned laurels internationally. It also gives information and advice in the field of remote sensing to other countries and earns valuable foreign exchange.

Sarabhai received many national and international honours. In 1962, for his scientific services in the field of physics, he was awarded the Dr Shantiswaroop Bhatnagar Memorial Award. In 1966, the Government of India honoured him with the *Padma Bhushan*. Thereafter, he was posthumously awarded the *Padma Vibhushan*.

In 1961–62 at the Indian Science Congress Sarabhai was appointed the president of the physics section. In 1968, at the United Nations' (UNO) Peaceful Uses of Outer Space Conference, he was selected Vice-president and Chairman. In 1970, at the 14th international general body meeting on Atomic Energy, he took over the charge as the President.

He believed that scientific research was a love towards Nature. In one sense, he was one step ahead of Homi Bhabha. In scientific institutions besides scientists he also understood the importance of administration. Like Bhabha, Sarabhai's death too was unexpected, unbelievable and untimely. He departed when he was just 52 years old. The International Astronomical Union has honoured him by naming a crater in the Sea of Serenity on the moon after him. In memory of this great scientist, every year, any scientist making extraordinary contribution in the field of satellite communications system, rocket engineering, meteorological science, astronomy, physics, space science or other sciences is presented the Dr Vikram Sarabhai Memorial Award. Besides, every year since 1977, one scientist from the top scientists of the country or abroad is appointed as Vikram Sarabhai

Professor for one year at the Physical Research Laboratory in Ahmadabad. The students and scientists of the institute get the benefit of the knowledge and guidance of this scientist.

The unexpected death of Sarabhai has been a great loss to the science world, and it cannot be filled easily. In his demise, Gujarat has lost a worthy son.

17

Dr Hargobind Khorana

An American citizen since 1965, Hargobind Khorana was born in India and his lifestyle and culture are Indian. This great scientist was born on January 9, 1922, in Raipur village of Multan district in West Punjab. His father was a village revenue officer. In a village of 100 houses, Hargobind's father was the only educated person. So it seems Hargobind's birth date is mentioned differently at different places. It did not seem important then. Some book mentions his birth date as January 1, while some other mentions it as January 2. Some even mention it as February. Such was the condition in this small village. Among four brothers, Hargobind was the youngest. He lost his father when he was still a young boy. After his father's death, his mother took over the family's responsibility and educated all the sons. Since there was no school in the village, a teacher from the neighbouring village would come and teach the children under the shade of a huge banyan tree. Hargobind too studied in this primary school amidst nature.

Hargobind was a brilliant child. He completed his primary education from Raipur and Multan, and his secondary schooling from Multan's DAV High School. He stood second in the matriculation examination. He got 18 marks less than the first placed student, which upset him terribly. The school principal Dinanath consoled him. Hargobind was a clever and intelligent child. The principal too had high expectations from him. For his graduation he joined the DAV College in Lahore. In 1943, he cleared BSc honours with a first class in chemistry from Punjab University. In 1945, he completed MSc from the same college. Meanwhile, the British Government awarded him a scholarship for further studies in England. In 1946, he left for England and registered for PhD at Liverpool University and in 1948, he received the PhD.

Meanwhile, on August 15, 1947, India was partitioned. His native place became a part of Pakistan. So, he and his family shifted to Delhi. When Khorana returned to India with a PhD degree, the Government of India extended his scholarship for one more year. He went to Zurich in Switzerland for further research and returned after a year. Due to lack of a suitable job, he shifted his attention abroad. He went to England and from 1949 to 1952 he studied and did research as Newfield Research Fellow at Cambridge University. For three years he got the opportunity to work with world-renowned scientist Alexander Todd on the structure of living organisms. In the meantime, he came in contact with a lady in Switzerland and married her. When a better opportunity came his way, he moved to Canada and joined the Biochemistry department of the British Columbia University in Vancouver and stayed there till 1960. During this time along with another scientist he researched on coenzymes. This brought him fame internationally. In

1958, the Chemical Institute of Canada gave him the Merc Award. In 1960, another leading institute there awarded him a gold medal. Since 1958, he served as visiting professor at Rockefeller Institute in America.

After arriving in America in 1960, he joined Wisconsin University in California State. He had now decided to settle here. In 1965, he received American citizenship. He was appointed as professor and joint director at the Institute of Enzyme Research in Wisconsin University. He worked there till 1970. In 1970, Khorana joined as professor of chemistry and biology at the Massachusetts Institute of Technology (MIT).

The research carried out by him and his co-workers in chemistry at Wisconsin University gave a boost to his career. He was interested in unravelling the genetic code. He synthesized each of the 64 nucleotide triplets that make up the code. In 1968, the Nobel Prize for Physiology and Medicine was jointly awarded to Hargobind Khorana, Marshall Nirenberg and Robert Holley. This prize was given for their research on deciphering of the genetic code.

The traits inherited by human beings from generation to generation are known as hereditary characteristics. This science is called 'genetic science'. Chromosomes play an important role in transferring the characteristics of parents to their children. Human beings, animals or vegetation have cells as units. At the centre of a cell is the nucleus. These cells mainly consist of a chemical better known as DNA (Di-oxyribo Nucleic Acid). DNA is in the form of tissues. These tissues join to form the chromosomes. For hereditary traits chromosomes are very vital.

Khorana made an important contribution towards the analysis of nucleic acid. He created nucleotides from simple chemicals and developed a method of arranging them in a pattern. After he received the Nobel Prize, he also received the American Chemical Society Award and

the Gibbs Medal. The Government of India honoured this son of the soil with the *Padma Bhushan* in 1969. His important researches after the Nobel Prize took him to greater heights. He was honoured with the Conrad A Elvezam professorship in the field of bacteriology. Dr Khorana is the member of America's National Academy of Science. This is a unique honour. He was invited to give the inaugural address at the seventh International Biochemistry Congress session held in Tokyo.

Khorana's next major achievement came in 1970, when he announced the synthesis of the first artificial gene. The same year he moved to Massachusetts Institute of Technology (MIT) where by 1976 his team had made a second gene, which was capable of functioning in a living cell. He was busy with his research group at MIT, which consisted of students from Japan, Germany, Britain, Australia, New Zealand, India and Nepal. More than 15 of them received PhD degrees under his guidance. Many of them completed their training and returned to their homelands to continue research with new teams.

On October 20, 1974, an international conference of physiological scientists was held in New Delhi. More than 1,700 scientists from all over the world participated. During this event, Khorana came to India after a gap of twenty five years. He was given a warm welcome. Many universities honoured him with honorary doctorate degrees. Thereafter in 1983, he again visited New Delhi, to attend the fifteenth International Congress of hereditary scientists.

Despite accepting American citizenship he has great feelings for his country. He continues to be in touch with his brothers and on auspicious occasions does all he can to contribute. By nature he is very polite. He continues to be engrossed in his research even today.

18

Dr Venu Bappu

The great Indian astronomer of the 20th century, Dr Venu Bappu, was born on August 9, 1927, in a cultured south Indian family. In the local primary and high school, he maintained top rank every year. After completing graduation and post-graduation with physics from Chennai (Madras) University with high ranks, he went to America for further studies. There he completed his PhD in astrophysics from Harvard University.

In 1949, when he was doing research in America, along with Prof Dr Bart John Bock and his senior colleague Bob New Kirk, he discovered a new comet. This comet was jointly named Bappu-Bock and New Kirk comet after the three discoverers. He became the first Indian astronomer to discover a comet. This comet after its long trip will show up again after 60,000 years.

His research area was soiar and celestial physics. It is a known fact in astronomy that red stars are considered cold and purple-coloured stars are very hot. The colour of a star shows its temperature. Besides being hot, purple-coloured stars have more of helium content. The Sun is a cold star. Similarly, Aldebaran, Polestar, Arcturus, Betelgeuse, etc., too are considered cold stars. When a spectral analysis of star is done, the composition of heavy elements is visible in the lines. Calcium in the cold stars shows its own line. Properties like the width of these lines as well as the absolute brightness and the absolute magnitude of the stars are related to each other. Bappu's research in this connection is known as the

Wilson-Bappu Effect. This was Bappu's major contribution to astronomy.

After returning from America, he joined the observatory at Nainital. After a short time he moved to Bangalore and settled there. There he set up the Indian Institute of Astrophysics and took active part in its development as founder director.

He achieved excellence in designing the optical telescopes and in preparing and grinding their lenses and mirrors. He contributed greatly in developing the Nainital observatory and in setting up the Kovalur observatory. He provided technical know-how for making 100 cm (40 inch) telescopes for various institutes in the country. Besides, under his guidance an infrared telescope lens with a diameter of 1.2 metres (48 inches) has been constructed at Bangalore, for the observatory of Physical Research Laboratory at Gurushikar on Mount Abu. In fact, he constructed various telescopes with lenses with a diameter of 37.5 cm to 100 cm (15 inches to 40 inches) in the country. He focused all his energy in constructing India's largest optical telescope at Kovalur. The lens of this telescope measures 2.25 metres (about 90 inches) in diameter. This largest telescope in the country is today known as the Venu Bappu Telescope in his memory.

He was a well-known figure internationally. For his contribution to astronomy, the Royal Astronomical Society of London honoured him by electing him as a Fellow. Belgium's Royal Society of Science made him an honorary member. He was president of the International Astronomical Union for three years, the only astronomer from India to chair such a post.

At home, he was presented the Dr Shantiswaroop Bhatnagar Award. The Physical Research Laboratory (PRL), Ahmadabad, honoured him with the Dr Vikram Sarabhai Professorship for 1982. Young researchers of astronomy, scientists and students got an opportunity to work and

interact with him. Earlier, in 1981, talking about comets at a lecture in Ahmadabad, he had shed some new light on Haley's comet. He had also given information about its reappearance in 1986. Haley's comet reappeared in 1986, but alas, he was not there to witness it!

In 1982, he gave two public lectures on Distances in Universe in Ahmadabad. In August 1982, he left for heavenly abode.

He was instrumental in putting the solar observatory at Kodaikanal on the world map. In his last days he suffered from kidney problems. For its treatment he was taken to Munich in August, 1982. He died during the operation. Thus, the sun set when it was at its peak, with the world and especially India losing a great astronomer.

19

Dr Abdul Kalam

Creator of missiles in independent India, a great scientist in the real sense of the term, and last but not least, President Of India, Dr Abdul Kalam, was born at the popular pilgrimage centre and island Rameswaram in the southern state of Tamil Nadu, on October 15, 1931. His full name is Avul Pakir Jainulabdeen Abdul Kalam. In short, he is known as A P J Abdul Kalam. He was born in a poor, but honest and cultured family. They stayed in the old ancestral house in Masjid lane of Rameswaram. His father was not very educated, but he

had other skills and was practical. The famous temple of Rameswaram was located just ten minutes away from his house. It was not very easy for his father to run this large family, but he was polite and hardworking. On his boat he used to ferry pilgrims from one bank to the other. Despite financial difficulties he admitted this bright child at the Rameswaram primary school.

According to Dr Abdul Kalam, as reported in one of his write-ups, some cultured Hindu families stayed near his place and among them lived the priest of the main temple of Rameswaram. The good values of this family influenced Kalam to some extent. He understood what was said in the *Bhagwad Gita* and in what context. Even today he remains a strict vegetarian and draws inspiration from the *Gita*. When he was a child he received a lot of love and care from this cultured neighbour.

When World War II ended, this 13-year-old boy asked permission to study at the secondary school at the district headquarters in Ramanathapuram. His father granted him permission and also accompanied him to the station. He gave his blessings and wished him well to move ahead. He was admitted at the Swartz High School run by Christian missionaries in Ramanathapuram and stayed at the hostel. Though his parents faced difficulties, they had kept his wish in mind and encouraged him to study. Kalam too made up his mind to take up as much responsibility as possible of his family. This bright and intelligent boy won the hearts of his teachers as well. They in turn helped him. For further studies, in 1950, he went to the nearby city of Tiruchchirappalli and joined the St Joseph College. Now, he had gained confidence. His English professor Father Sequiera was his hostel warden. He stayed there for four years. In the last year of his college he got interested in physics. After his BSc he joined the Chennai (Madras) Institute of Technology (MIT), and chose the aviation engineering course. He was

clear that he wanted to become a pilot. He obtained the DMIT after three years of his study, standing first in the examination.

After completion of his MIT course, he joined the Hindustan Aeronautics Ltd., Bangalore as trainee. When he successfully completed his training and graduation in aeronautical engineering, he had two opportunities. Both of them were to his liking. One was to join the Air Force and move ahead as a pilot. The other was to join as Director of Technical Development and Production (DTD&P), under the Ministry of Defence. He sent applications to both and was called for interview at both places. After reaching Delhi he appeared for the interview and it went off as he had expected. One week after this interview he was to present himself before the Air Force Selection Committee in Dehradun. Here besides physical fitness many other aspects were to be taken into consideration. It was a slightly different kind of interview. Eight candidates were to be selected from 25 candidates. He came in the ninth position. He felt he had lost the opportunity and was sad too. From there he went to Rishikesh. After having a dip in the holy Ganga, he felt at peace with himself. He then went to the nearby *Shivanand Ashrama*. He was impressed to see the Swamiji. He met Swami Shivanand. Smilingly, the Swamiji asked him the reason for his sadness. His having missed an opportunity to work in the Air Force had pained him, he told the Swamiji. With a reassuring demeanour Shivanand said, nobody can change destiny. What was destined to happen has happened! Therefore, don't despair. Probably, it must have been for the better. Resign yourself to God's wish. Talking to Swamiji he felt at peace with himself. Bowing before him he took leave and came to Delhi.

Shortly, he received an appointment letter to join duty as Senior Scientific Assistant at a monthly salary of Rs 250. It happened as it was destined. He stayed in

north India for three years. In between he stayed for a year at the industrial town of Kanpur. He met different kinds of people. But his mind always pined for the quietude of Rameswaram.

He was then transferred to the newly established Aeronautical Development Establishment (ADE) in Bangalore. He came to Bangalore to take charge and after some time a group of four scientists was formed under his command. The group was given the responsibility of building an indigenous hovercraft in three years. The then Defence minister V K Krishna Menon wanted the work to be completed at the earliest. When he visited Bangalore, he would make it a point to see the progress of the project. The hovercraft was named 'Nandi' after Lord Shiva's vehicle. A temporary model that could lift 550 kgs payload was also prepared. Thereafter, Krishna Menon left the Defence ministry and the project too, was shelved. Once, the head of the establishment told Kalam that a dignitary was coming to see the project. The dignitary came on the appointed day. He inquired in detail about the project and its progress. He asked various questions. Kalam had no inkling who this gentleman was. Actually, he was the director of the Tata Institute of Fundamental Research (TIFR), Professor M G K Menon. Some time later the Indian committee on space research called Kalam for an interview at Mumbai (Bombay) for the post of rocket engineer. Dr Vikram Sarabhai and Prof Menon interviewed Kalam and then invited him to work in the space research department. Kalam was quite impressed by the way Dr Sarabhai conducted the interview. He had decided to take up the offer of the space research department. The next day he was told that he was selected as rocket engineer in the space research department. The following day onwards his necessary basic training in the computer department of TIFR started. According to him, the environment at

the space research institute was genial and totally different from other government departments. By the end of 1962 it was decided to set up a rocket launching centre at Thumba in Kerala. Kalam was selected to visit NASA (National Aeronautics & Space Administration), America for six months training in rocket launching. He went to his native place to meet his father and other family members. The whole family was thrilled to hear that he had got an opportunity to go abroad. His father thanked God. Tears of joy welled in everyone's eyes.

Six months later, Kalam returned to India. The country's first rocket Nike–Apache was gifted from abroad. It was decided to send this rocket into space on November 21, 1963. Kalam had taken care of all the technical responsibilities. After its success the mood of scientists and technicians was very upbeat. At a meeting called by Dr Sarabhai it was decided to march forward in the direction of making satellite launch vehicles (SLV) and artificial satellites. Thereafter, on November 20, 1967, the Rohini–75 rocket was sent into space from the Thumba station.

In February 1969, the then Prime Minister Indira Gandhi opened the equatorial rocket launching centre at Thumba for international space research. This ensured scientist from any country to make use of the facility at the experimental station. Meanwhile, in 1968, the Indian Rocket Society was established. To the east of India, around 100 km north of Chennai, at the Sriharikota island, the country's second rocket launching centre was set up. India's national space research committee (INCOSPAR) was re-constituted and the Indian Space Research Organisation (ISRO), a new government agency was established.

In the initial 15–20 years after we attained independence, the Army had to totally depend on foreign help for spare parts and other defence material. Foreign

powers pushed their old and outdated army machinery to the developing countries like us. As if doing a favour, they provided the equipment and also earned lots of money. To overcome this shortfall, the Integrated Guided Missile Development Programme (IGMDP) was started. Its entire responsibility was given to Kalam. Despite facing economic difficulties, he took forward this programme, working for 12 to 15 hours a day. For this, he undertook a deep and detailed study of missiles and found four types of missiles absolutely necessary.

As head of the Rohini project, Kalam did a wonderful and successful job. His biggest gain was the opportunity he got to discuss and interact with experts in various subjects. At ISRO, he worked on the satellite launch vehicle and successfully launched the SLV–3. He came to realize that technology can be used to further the development of missiles. Today Kalam is grateful to Dr Sarabhai for his guidance and vision.

Even after joining the space department, the Defence Research and Development Organization (DRDO) availed of the services of Kalam. He was in close touch with the organization. The group of scientists there had helped him in developing missiles. Kalam had contributed the most. The rocket tipped with bombs is known as a missile. Missile is actually a destructive weapon. It has nothing to do with the rocket used in space flight. Missiles can be fired from aeroplanes, submarines or from the ground. The missiles that can be controlled by radio waves or through some internal mechanism are termed as guided missiles. These missiles can locate their assigned target at the fixed place. Antimissiles are used to stop the fired missiles on their tracks and destroy them. Initially, Germany, America, Russia and China used to produce missiles. India has begun producing various missiles like Prithvi, Aakash, Nag, Agni and others. India is the sixth country in the world to produce missiles.

On December 30, 1971, after attending a panel meeting in Delhi, Kalam was returning to Thumba. On that day Dr Sarabhai was in Thumba. Kalam telephoned him from Delhi and told him about the meeting. Sarabhai told him that he was going to Mumbai. Kalam expressed the desire to meet him at the Thumba airport. But when Kalam reached Thumba he came to know that a few hours back, Sarabhai had left for heavenly abode. The charge of the space department was handed over to Prof Satish Dhawan. Dhawan entrusted Kalam the SLV-3 programme as the manager.

In 1975, ISRO became a government organization and came under the space department. In 1976, Kalam's father passed away at the age of 102 years. Some time later his mother too died.

Once again plans were afoot to move Kalam from ISRO to the Defence Research and Development Laboratory (DRDL). From June 1982, he took charge as its director. Some time later, commending his services the Anna University of Chennai conferred on him an honorary doctorate degree with Prof Raja Ramanna as the chief guest of the function. On January 26, 1981, he was conferred the *Padma Bhushan*.

Meanwhile, on the morning of July 18, 1980, at 8.03 hours, the Indian satellite launch vehicle SLV-3 was successfully launched from the Sriharikota range. All the stages were carried out perfectly and the Rohini satellite was placed in orbit at the schedule time. When Kalam came out of the centre's premises, elated colleagues lifted him on their shoulders. Immediately the success of the programme was announced on radio and TV. The then Prime Minister late Smt Indira Gandhi congratulated the entire team on its success. India became the fifth country to achieve such a feat.

Thereafter, the improved ASLV was produced, where the payload was increased from 40 kg to 150 kg. On

June 26, 1984, under his leadership the 'Devil Mission', especially developed for the army was successfully tested. To see its progress, the Prime Minister late Shri Rajiv Gandhi visited the site. In August, 1985, Kalam was invited by the American Air Force to pay a visit to their facilities. Along with him, three other colleagues were also invited. On September 16, 1985, the Trishul missile was successfully test fired from the Sriharikota testing range. On the morning of February 25, 1988, at 11.23 hours, the Prithvi missile was successfully test fired from SHAR. This missile can carry a bomb load of 1,000 kg and fire at a distance of 150 km. Western nations displayed concern and veiled threats over its success. Seven countries decided not to deliver the necessary raw materials to India. On the morning of May 22, 1989, at 7.10 hours, the 'Agni' was successfully test fired. On Republic Day, January 26, 1990, Kalam was conferred the *Padma Vibhushan*. Jadavpur University and then IIT Mumbai conferred on him honorary doctorate degrees.

Kalam was made the Director of the Defence Research and Development Organization. Then he was appointed as Scientific Advisor to the Defence minister. On November 25, 1999, he was appointed as the Principal Scientific Advisor to the Central Government.

He was accorded cabinet minister rank. He then became scientific advisor to the Prime Minister advising and guiding him on scientific development and various scientific and technical policies for different departments.

The Central Government honoured Kalam for his services with India's highest award, the *Bharat Ratna*. Besides Kalam, 28 other distinguished persons have till now received India's highest award. Kalam is the youngest scientist to get this award.

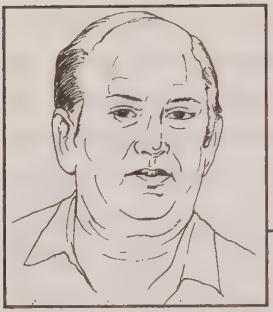
He developed the surface-to-surface Prithvi missile for the Indian Navy. It can take a payload of 1,000 kg

to a range of 250 km. It can be used as a war weapon. He has developed the supersonic system, which can destroy the enemy warships. For the Air Force too he has developed a powerful missile. This missile can be fired from air-to-surface. Now he is making it more effective with the radar system. This way pilotless planes can themselves detect enemy planes and target them. Making plans till 2020, he has also published a book, 'India–2020'.

Kalam resigned from his post of Chief Scientific Adviser to the Prime Minister and planned to serve science. He joined the Anna University of Tamil Nadu. Meanwhile, the National Democratic Alliance requested him to contest the presidential election. With a very good majority he was elected as President of our country.

On July 25, 2002, he was sworn in as President of India by Shri B N Kirpal, Chief Justice of the Supreme Court of India. Kalam became the 12th president of our country.

Always smiling, Kalam is simple, humble and soft spoken. He patiently listens to friends and colleagues and explains to them in a simple and easy way. We wish and pray to the almighty that this great and simple scientist and now the President of India continues to serve the country and make progress in his endeavours.



20

Prof U R Rao

Considered one of the leading space scientists in the world, Dr U R Rao was born on March 10, 1932, in Admar village in the south Canara district in Karnataka state. His father's name was Lakshminarayan Rao and his mother's name was Krishnavalli. His full name was Udupi Ramchandra Rao. He completed his school and college education from a place near his village. Very fond of reading during his school and college days, he was among the top rankers in class. He passed BSc with a first class in physics and joined the Varanasi (Benaras) Hindu University for his post-graduation. In 1953, he passed MSc with a first class. The same year he went to Ahmadabad and joined the Physical Research Laboratory (PRL) for his PhD and began research on cosmic rays under the guidance of Dr Vikram Sarabhai. In 1960, he received PhD. For further studies, in 1961, he received post-doctoral fellowship from the Massachusetts Institute of Technology, Boston. There he carried out further research on cosmic rays and solar winds. After two years of research here, he worked as assistant professor at South West Centre for Advance Studies in Texas University, from 1963 to 1966.

In 1966, he returned to India and once again joined PRL as Fellow and continued with his research. Thus, began his second phase of life. Here he began research studies on X-rays and gamma rays in cosmic rays. These experiments involved use of balloons, rockets and satellites, which were used as payloads. Meanwhile, Rao served as associate professor at PRL from 1968 to 1970.

In 1970, he was promoted as professor. He worked on that post for two years. In 1972, he was appointed as director of ISRO Satellite Centre in Bangalore. He successfully discharged his duties here till 1984. During his researches at PRL, he and his colleagues had made important contributions towards understanding the interplanetary medium. His research on solar winds has increased our understanding of the subject. The data interpretation of American satellites Pioneer I and Pioneer II became easy due to his researches. His understanding of the solar winds by unravelling the American satellite Mariner II observations provided a new insight to the world of science. He was the first to establish the relationship between geomagnetic storms and solar winds with the help of observations made on earth. For his highly accurate analysis of the Pioneer 6, 7, 8, and 9 observations, he was awarded the 'Group Achievement Award' by National Aeronautics & Space Administration (NASA) in 1973.

His third phase of life started with his appointment as director of ISRO Satellite Centre at Bangalore. After his return from America, his second phase was spent at PRL, where he received guidance from Dr Vikram Sarabhai whenever he needed. At Bangalore, he started development of the new institute and after Dr Sarabhai's death, fully concentrated on enriching the space department and reinforcing the satellite technology. This resulted in the design and construction of India's Aryabhatt satellite in 1975, under his guidance. This was successfully launched from the Russian Cosmodrome and was well in control thereafter. Then the design, development and successful orbit of Bhaskar I and II were carried out in 1979 and 1981. Under Rao's leadership, the first experimental geostationary satellite 'Apple' was put into orbit in June, 1981. This gave a boost to the development of this new technology in the country. Thereafter, the Indian Remote Sensing (IRS) satellites and the INSAT satellites for

broadcasting and meteorological purposes were designed, developed and successfully sent into orbit. The success achieved in putting them in appropriate orbit has increased the faith in Indian scientists and technicians. All this happened under Prof Rao's able leadership.

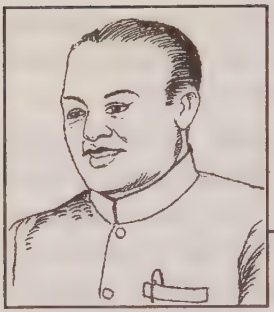
On October 2, 1984, Prof Rao was appointed chairman of ISRO and secretary of Space Commission, Government of India. He was entrusted the entire responsibility of the country's space programme. Taking forward the programme by guiding the scientists and engineers, he performed his duties successfully till 1994. Under his leadership the country's space programmes took a giant leap and made various achievements. During his tenure, satellite launch vehicles were produced. This achievement was recognized. Launch vehicles like the ASLV, which could launch a satellite with a payload of 150 kg in lower orbit and PSLV, which could launch a satellite with a payload of 1,000 kg in polar orbit were prepared. Besides, special cryogenic engines are acquired to produce launch vehicles for GSLV geostationary satellites. These satellite launch vehicles can put satellites with 2.5 ton payload into orbit.

Prof Rao has played an important role in enhancing India's name in the world of space science. This is the reason why many institutes, universities and many governments in the country and abroad have lauded his efforts. In 1975, the Russian Science Academy, while praising his efforts for the successful launch of Aryabhatt satellite, honoured him with the Russian 'Medal of Honour'. The same year, he was awarded the 'Dr Vikram Sarabhai Research Award' instituted by the *Hariom Ashrama*, for his contribution to space physics. He was also awarded the 'Dr Shantiswaroop Bhatnagar Prize' for his contribution to engineering science. The Karnataka government conferred on him the 'State Award'. In 1980, the Indian Engineering Institute gave him the 'National Design Award' and for his contribution to electronics

science and technology, he was given the year's 'Vasvik Research Award'. For his services to the country, the President conferred on him the *Padma Bhushan*.

In 1987, the National Science Academy awarded Rao the 'P C Mahalanobis Medal'. In 1991, the Russian Space Flight Federation honoured him with the 'Yuri Gagarin Medal'. In 1992, for his cooperation in the journey of space, the international community (of which he is the Vice-president) awarded him the 'Allen D'mil Memorial Award'. In 1995, India's scientific community honoured him with the 'Aryabhatt Award'. The same year he was given the 'Bhasin Award'. Kolkata (Calcutta) University along with Mysore University, as well as other universities in the country and abroad have conferred on him honorary doctorate degrees. The National Science Academy, Institute of Electronics and Telecommunications, National Engineering Academy, and Indian Astronautical Society have honoured him with a Fellowship and gave him honorary membership. He is the president of the Indian Rocket Society. He was honoured as visiting scientist to Texas University and other universities. In 1996, he was presented the 'Dr Vikram Sarabhai International Award'.

Today, he works as chairman of the PRL governing body. Besides, he is associated with various institutions. He has to his credit, more than 150 research papers. He has also written a book on the Aryabhatt project with his colleague Dr Kasturirangan. It describes in detail about the project, its results and also analysis of its images. In 1996, he had detailed discussions with the then Prime Minister Narasimha Rao, on how science and technology would be useful in increasing foodgrain production, economic development and health of the country, and wrote a book in this connection. Thus, he has served the country in various fields. We pray to the almighty to grant him good health and long life, so that he continues to guide the country in space research.



21

Dr Jayant Narlikar

The great Indian astrophysicist, Dr Jayant Narlikar was born on July 19, 1938, in a highly educated and cultured family in Kolhapur district of Maharashtra. His father Prof Vishnu Vasudev Narlikar was the Head of the Department of Mathematics at Benaras Hindu University. Thereafter he was Chairman of the Rajasthan Public Service Commission. Jayant Narlikar had his education in Varanasi. His mother was a graduate in Sanskrit from Mumbai (Bombay) University. Besides, she loved English literature. She was graceful, cultured and educated lady.

Young Narlikar was exceptionally talented and always topped at school and college examinations. Mathematics was his favourite subject. Besides, he enjoyed reading. In 1959, he cleared BSc Honours from Benaras Hindu University. He stood first in the University. His subjects were mathematics and astrophysics. For further studies his father wanted to send him abroad. Before leaving India, he was informed by those who had already been to England, not to be complacent. Life would be tough but having worked hard, he came out with flying colours. The advise he received from his father and particularly, his maternal uncle Dr Vasantrao Hujurbazar really stood him in good stead.

Besides his parents, Fred Hoyle, his teacher and mentor had a great influence on him. Besides, his extraordinary result at the graduate level also fetched him a scholarship. He was sent to England, where he joined Cambridge University. Here he obtained MSc degree

in just two years. Incidentally, at that time a world famous teacher of astrophysics was in Cambridge. He was, Frederick Hoyle, better known as Fred Hoyle. Hoyle was professor at King's College, Cambridge and conducting research on the speed and condition of celestial bodies. Narlikar registered for PhD under Hoyle and began research work. Hoyle accepted him wholeheartedly. In 1963, Jayant Narlikar was awarded PhD by Cambridge University. He stayed in Cambridge from 1957 to 1962.

During his 15 years stay abroad Dr Narlikar made many important researches. At the age of 22 years he became member of the Royal Astronautical Society. He was also appointed Fellow at King's College, Cambridge. His father too, was member of this institute. His PhD thesis included research on principles of gravitation, gravitational pull between different celestial bodies, formation of the universe and others. He had also presented another view to the popular Big Bang theory. According to his theory the universe is not expanding but static (still). He had described it as 'steady state'. This theory shed new light on the subject. With Fred Hoyle, he presented the famous **Conformal Theory of Gravity**, which became well-known all over the world. Narlikar and Hoyle worked on cosmology, including the steady state theory, theory of gravitation, electrodynamics, etc. They propounded that the force of other powers in space and the universe has an effect on the mass of matter. Besides, it also affects the shape and size of matter. It is generally believed that the gravitational pull depends on the mass of the object. He suggested that the gravitational pull on celestial bodies depends on its density. As the internal density of the object is more, so is the gravitational pull. This is the reason why such heavenly bodies try to devour other heavenly bodies. As the mass of these objects increases it becomes dense. Its density increases so much that such a pinch of mass is equivalent

to several tons in weight. In the end it becomes a Black Hole. Such objects do not even allow light to escape from them.

His researches on gravitation of space objects are considered noteworthy. He received awards and medals from many institutes in Europe. In 1969, the Union Education Ministry invited Dr Narlikar and Hoyle to visit India and deliver lectures.

In 1968, Cambridge University honoured him by presenting him the Adam Award. Earlier, three Indian scientists had received this prestigious award: in 1944, Dr Homi Bhabha; in 1948, Dr S Chandrashekhar; and in 1961, Dr Hujurbazar. This award is given every two years in the memory of Dr J C Adams, for path breaking research in the fields of mathematics, astrophysics and natural science. Adams was an outstanding astronomer, who had predicted the existence of planet Neptune in 1846.

Narlikar married Mangala Sadashiv Rajwade in 1966. In 1969, when he returned to India, he was conferred the *Padma Bhushan* by the Government of India. Mumbai's Tata Institute of Fundamental Research invited him to join as professor of astrophysics. Narlikar too had decided to offer his services to the country. In 1972, he joined TIFR as professor. Besides research and teaching, he guided doctoral students. Here he continued research on tachyons. Tachyons are particles that move faster than the speed of light. According to Dr Narlikar, Black Holes are bases of tachyons. They absorb light coming from outside and with tremendous pressure contracts the surface of the Black Hole.

After coming here Narlikar developed one more activity. To popularize science and especially astronomy among the people he wrote a book AKASHASHI JADLE NATE ('Related to the Sky') in his mother tongue Marathi. Besides he also wrote science stories. His books have

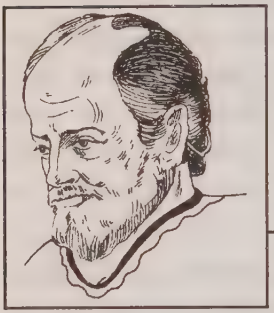
also been translated into Hindi and Gujarati. He is an accomplished science fiction writer.

In September 1988, the late Prime Minister Rajiv Gandhi encouraged him to start an astronomy and nuclear physics inter university centre. Through the University Grants Commission and central aid such a centre has been made possible. Narlikar was its first director and worked as Homi Bhabha professor. In 1988, he attended an international conference on astronomy at Baltimore in America.

On January 10 1989, the National Science Academy honoured Narlikar with the Venu Bappu Memorial Award for 1988. This award includes Rs 25,000 in cash and a medal. In 1990 he was awarded the Indian Science Academy's Indira Gandhi Award and in 1996, UNESCO's 'Kalinga Award'. Recently, on March 12, 2003, the 'Yashwantrao Chavan Rashtriya Puraskar–2002' was presented to Narlikar.

We pray to the almighty to grant good health and long life to this great Indian scientist, so that he may continue to serve the world of science and the country.

(B) FOREIGN SCIENTISTS



22

Archimedes

The great scientist and mathematician Archimedes was born in 287 BC at Syracuse in Sicily, near Italy. His father Phidias was a famous astronomer of Alexandria. Archimedes was admitted to one of the reputed mathematics school in Alexandria. In Greece of those times this mathematics school was considered among the top schools in Alexandria. The famous mathematician and Euclid's successor, Xenon of Samos, was Archimedes' teacher.

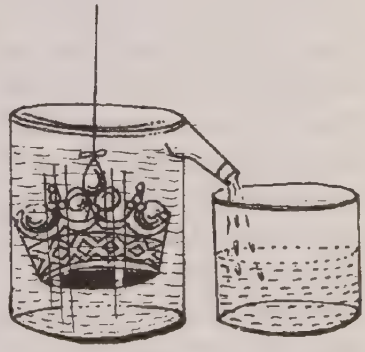
Archimedes spent most of his life in introspection and mathematical studies. The Greek society of that time looked down upon physical labour. Experimental studies invited frowns. But many scholars believed then that before Archimedes presented any mathematical formula, he would have practically solved it. Archimedes neither discussed nor mentioned about his mathematical experiments with proofs. Certain scholars believe that many a time Archimedes may have mentally arrived at the conclusion (solution) and where necessary, solved the same experimentally.

There is a popular and the most successful experimental proof he provided in solving a problem presented by King Hieron. Hieron wished to know whether a newly-made crown, supposed to be of pure gold, was as

he had suspected made partly of silver. Having grasped the simple concept of relative density, Archimedes solved this problem. He successively immersed the crown itself and later pieces of gold and silver of equal weight in a full container of water and noted the weight of water displaced in each case. Thus, Archimedes was able to show that the crown was indeed not made of pure gold without the need of melting the crown.

Archimedes dwelt on the problem at length. Totally engrossed, he went into the bathroom the next day. When he sat in the bathtub, he realized that the water level had gone up. His mind started working. An idea struck him that the study of this phenomenon can measure the volume of any object with an irregular shape. When he discovered the principle of the upthrust on a floating body, he was ecstatic and shouting Eureka! Eureka! (I've found it), he ran outside naked.

Let us try to understand how he came to the conclusion. First, he filled the vessel with water to the brim. Then, he carefully immersed the crown in it. Whatever water displaced was collected in another container. He measured its volume. He logically concluded that the volume of the crown is equal to the volume of this water. Now, the solution to the king's problem seemed in sight. The volume of the displaced water should be equal to the volume of gold given to the goldsmith to prepare the crown.



An experiment to find the volume of a crown

The king came to realize that while making the crown the goldsmith in his greed had added some silver to the gold. The goldsmith admitted of wrongdoing and was punished. Archimedes told the king and his courtiers that

the volume of any body and the volume of the water displaced when the body is immersed in water are equal.

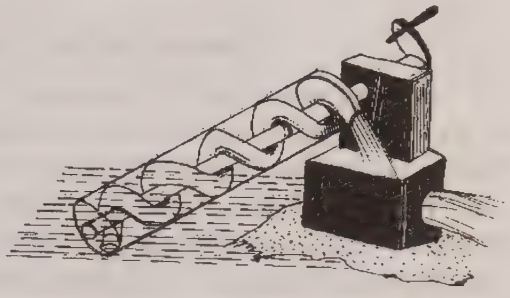
Thus, the volume of any body can be obtained. This resulted in the knowledge of specific gravity of any substance. The term **specific gravity** or relative density, as it is known today, is his contribution to science. It is the ratio of the density of a substance to the density of water.

He also explained that the specific gravity of gold is approximately 20. It means that the weight of 1 cubic cm or 1 cm^3 of gold is equivalent to 20 grams. Dwelling more on the subject he explained why a body floats in water and propounded the Law of Floatation. A light body like a log of wood if thrown in the water goes down and then floats on the surface. A heavy metal body like iron, if kept on the surface, sinks. Why does this happen? While having bath in his bathtub he realized that when a body falls in water, the water pushes it in the upward direction. That body which is heavier than water, has its weight reduced equivalent to the force applied by the upthrust. But in the end, it sinks in water. The weight of a light body like a log of wood is also reduced, but it floats in water. Here, Archimedes also explained certain terms like upthrust, floatation, etc. Thus, he not only solved the king's queries but also shed light on how to calculate the volume of an irregular shaped body, about specific gravity and the law of floatation.

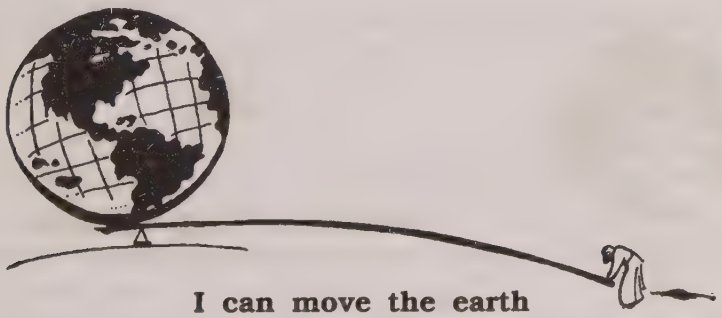
To explain it better he even gave an example. Suppose the weight of a piece of iron is 8 grams. If this piece of iron is immersed in water, and the weight of water displaced is suppose 1 gram, this means that the upthrust is 1 gram. This reduces 1 gram from the iron's original weight. Therefore, in water the weight of iron will be $8 - 1 = 7$ grams.

We can describe Archimedes principle as: When any body is immersed in a fluid, there seems to be apparent loss in weight of the body. The loss in weight of the body is equivalent to the water displaced by the body.

Archimedes designed a simple device like screw that could lift water. It is a long cylindrical device, fitted with a spiral screw. This screw lifts water. Many present-day equipment work on such a principle. Using a similar arrangement grains can be shifted from one height to another or shifted from one place to another. It can be called screw-driven arrangement. Archimedes was the first to use such a principle.

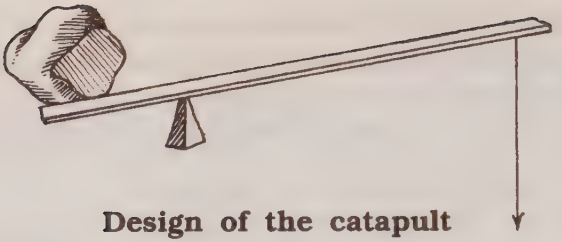


Archimedes' screw



I can move the earth

"Give me a firm place to stand on and I will move the earth!" is a saying ascribed to Archimedes, who discovered the laws of the lever. Archimedes knew that by using a lever one could lift the heaviest of weights by applying even the weakest of forces. One had only to apply this force to the lever's longer arm and cause the shorter one to act on the load. The principle of lever is useful even in our daily life.



Design of the catapult

During war times Archimedes had helped the state to a great extent. He had devised a catapult built on the lever principle. Archimedes' devices of war were used against the Romans during the siege of 215 BC. The enemy suffered heavy casualties and great damage. In the end the Romans emerged victorious and in 212 BC, took the city of Syracuse. The commander ordered that Archimedes be taken as a hostage giving full respect to his stature. Despite this order a Roman soldier accidentally killed Archimedes. The Romans laid his body to rest with full state honour.

23

Nicolaus Copernicus

Nicolaus Copernicus was born on February 19, 1473, in Torun city of Poland in Europe. His father's name was Copernide and his mother was Barbara. Nicolaus was the youngest among two sons and two daughters.

Torun was a big and prosperous trade centre at the time of the birth of this great scientist, astrologer, mathematician and philosopher. His father was a scholarly magistrate of the city. Besides, he was a rich, cultured, distinguished social worker and a well-wisher of society.

When Nicolaus was 10 years old, his father died. The children were then put under the care of their uncle Lucas. His uncle was a priest and educationist. He was a respected figure in society. It was but natural for the children to be brought in a cultured and religious environment. Young Nicolaus had made up his mind to become a preacher and accordingly focused his energies in this direction.

At the age of 18, Copernicus joined the Cracow University in Poland's capital Cracow. It was a well-known institute at that time with some of the best teachers in the land. A highly reputed institute, it attracted intelligent students from as far as Germany, Hungary, Italy, Switzerland who came here to study. Latin was prominent and important medium of instruction. To have a better understanding of literature, science and other subjects, it was essential to know Latin. After joining the university, Copernicus too gained proficiency in Latin. He then started taking deep interest in astronomy, geometry (mathematics) and geography besides other important areas of study then.

It was a time when Columbus was successful in discovering the new continent of America. Copernicus was 10 years old then. With time, sea voyages were on the rise and with bigger ships and increasing sea travel, more emphasis was laid on astronomy. The need for accurate almanacs was felt, for festivals were celebrated according to the dictates of the church. Such was the state of society during that period.

Copernicus' education took a different turn. In 1496, after leaving Cracow University, he joined Bologna School of Law in Italy. From here he moved to the famous Padua University where he studied medicine during 1501–1505. Thereafter, he took his Doctor of Canon Law degree from Ferara University and he arrived at his uncle's place in Poland. Discussions and deliberations with his uncle who

was a priest led to the conclusion that his doctorate would be useful in taking up religious work. It was believed then that medicine and astrology were closely related. Once again Nicolaus went to Padua University and joined the School of Medicine.

The famous astronomer and mathematician-scientist Ptolemy (90 AD to 168 AD) was born in Alexandria, Egypt. In the second century it was a big port city, besides being the cultural capital. To enhance their knowledge, intellectuals and thinkers from the country and abroad visited its well-stacked libraries and imposing museums in this city. Greek scholar Ptolemy, too visited this city many a time for his study. In 150 AD, Ptolemy had made some important observations regarding the motion of celestial bodies. Though he did not entirely understand many peculiarities of these heavenly bodies, he believed in what he saw and accepted the prevailing belief that the earth is stationary and the entire universe revolves around it. Therefore, he believed in the seeming truth that the Sun rises in the East and sets in the West.

Four centuries before Ptolemy, another Greek philosopher and astrologer had come to the conclusion that the Sun was the centre of the universe, but puritans did not heed to his conclusions and he was criticized. Ptolemy was influenced by popular belief. Accepting the geocentric (having the earth as centre) theory of the universe, Ptolemy based his calculations on it in his volume 'The Great Treatise of Astronomy', better known as 'Almegaste'. Hence certain flaws appear in his calculations.

In Greek, 'planet' means 'something that wanders on its own'. It had become an acceptable fact with philosophers, religious teachers and scientists, propagating the belief that the earth was stationary and the Sun and other planets revolved around the earth. Ptolemy, the great scholar tried to explain the planetary motions and

their positions, of which only some were true. Regarding the wrong calculations he had made, he justified them by calling them wandering celestial bodies. Poland's famous scientist Copernicus was able to understand the complex planetary motions of these celestial bodies, but for this he had assumed that the Sun was at the centre of the universe.

It was by now clear that Sun and other planets revolved in orbits. During one such revolution, a celestial body in radial motion moves 360°. This circle is divided into 12 parts each of 30°. These are known as the Zodiac signs. Today we know that the Sun moves from one Zodiac sign to another, every month. Thus, in one year, the earth completes one revolution around the Sun.

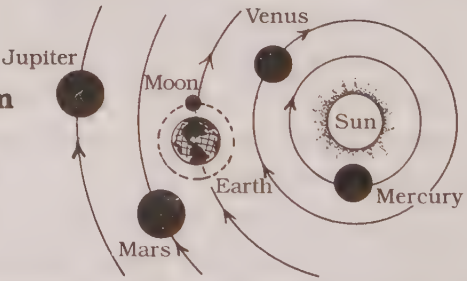
It was also believed then that there was an unknown link between the planets, Zodiac signs and the various organs of the body. On this basis and taking into account the birth time, astrologers draw the life chart of a person. Today too, people pay a lot of money to astrologers to know their future. In ancient India, Aryabhatt, Varahmihir, Brahmgupt, Bhaskaracharya and other astronomers were popular as astrologers.

During his learning years, Copernicus got a job as a junior priest in a church. Thus he received knowledge of science, religion and philosophy. Besides, he had studied law, which gave him a deep insight into the laws governing the church. Add to this his knowledge of Greek and Latin, and he was a well-versed scholar at the age of 33. He returned to Poland to serve his ailing uncle. Here his leisure hours were spent in independent study. This gave him a new insight into the universe and a scientific approach also. Initially, he accepted the ancient Greek and Arab calculations as they were. He had no appropriate instruments, but his was a thinking mind that worked wonders. On the basis of mathematics and philosophy he visualized the universe as a divine arrangement and

made some observations. But all these remained in his notebooks.

This is precisely what took him to the peak of his popularity. In 1539, a 25-year-old German student named Georg Rheticus came to him. This bright young man impressed Copernicus. At 28, he joined Wittenberg University as professor. For two years Rheticus made a deep study of Copernicus' notes and calculations. He came to the conclusion that Copernicus' observations were very noteworthy and needed to be published. Taking into account the motions of planets Copernicus had classified them. He had clearly stated that the Sun is at the centre of the universe and all planets including the earth revolve around it. He had developed a theory based on it.

Taking all these theories into account along with his theories, he wrote a treatise. But fearing a religious



The solar system according to Copernicus' calculations

backlash due to Ptolemy's widespread influence at that time, he did not get it published.

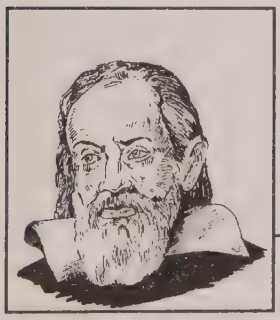
In 1543, with Copernicus falling ill, Georg Rheticus and his other friends took his permission to get his treatise printed and took it to Germany. The book was named De revolutionibus orbium coelestium (The revolution of the heavenly spheres). The credit for getting Copernicus' notes printed in book form goes to Rheticus to an extent.

When the printed book reached Copernicus, he was on his deathbed. He was in no condition to pass judgement

or appreciate it. His heart had gone weak and his brain almost dead. He died soon after seeing the first print of the book in 1543.

Many rank this book along with Newton's Principia. It sowed the seeds for discarding Ptolemy's famous theory. Old and superstitious beliefs were given a burial and the path to the development of modern astronomy was thus laid.

Fourteen centuries after Ptolemy had propounded his geocentric theory, Copernicus had presented his heliocentric theory. The stamp of religion was paramount at that time and no one dared oppose it. With Copernicus' theory it was the dawn of a new era.



24

Galileo Galilei

Eminent astronomer, physicist and seeker of truth– Galileo Galilei was born on February 15, 1564, in Pisa, a town in Italy. His father Vincenjio Galilei was a wool trader. Galileo belonged to a upper-class family, but their economic condition was not so good. He was the eldest in the family of seven brothers and sisters. His father studied music and was a music lover. Galileo inherited this trait. Since childhood he played the flute very well and was a good hand at drawing. He was an intelligent child, who designed various toys. This artistic streak made him popular among the local folk.

At that time Pisa town was part of the Tusque state of Italy. It was the centre of art and knowledge. Galileo's childhood was spent in this artistic and literary environment. It is a coincidence that this great scientist and England's famous playwright William Shakespeare were born in the same year.

At a young age Galileo was sent to the local school to study under the priests. Actually, he learnt more from his father than at his school. In 1581, at the age of 17, his father admitted him to the Pisa University to study medicine. But his mind was set on mathematics. Meanwhile, coming in contact with a scholar mathematician, his interest in mathematics became strong. Gradually, he gained mastery over mathematics.

Meanwhile, at the age of 20, he made his first discovery public. At a cathedral in Pisa, he noticed a hanging chandelier from the ceiling swinging in the breeze. He counted his pulse and measured the time taken for one oscillation of the chandelier and found that there was regularity in its swinging. At the end of his study he concluded that if we swing pendulums of equal lengths at any speed, the time for one swing remains the same.

He also demonstrated practical application of his discovery of the pendulum. Patients undergoing treatment can measure their pulse with a pendulum. He also visualized a watch based on a pendulum, but did not make it. Some time later Christiaan Huygens made a clock using a pendulum. It showed the minutes and seconds. Thus, his pendulum also served a practical purpose.

In 1585, he went through a financial crisis. This resulted in his abandoning midway his university education though he continued with his self-study. Now, his interest centered on mathematics. On the basis of his study, he openly criticized Aristotle's laws of motion. His deep study

and fascination for mathematics came to the knowledge of the local grand Duke. The Duke appointed Galileo as professor of mathematics at Pisa University. This did not bode well with the other professors of that time who were jealous of the appointment of this 25-year-old new professor. Moreover, Galileo did not even possess any university degree. He also raised questions on laws propounded by Aristotle. His courage to question the truth of Aristotle's laws irked the senior professors who openly displayed it.

Leaning Tower of Pisa

On seeing a falling stone and leaf, Aristotle had concluded that the lighter object would take more time to cover equal distance to the ground. Galileo reasoned that it was due to the obstruction caused by air. Galileo took two stones of different weights and dropped them from Pisa's famous Leaning Tower. Though both stones varied in weight they fell on the ground at the same time. Galileo proved his point and questioned Aristotle's hypothesis. Though the senior professors were present during the experiment, they were reluctant to accept it.

It was a time when stop clocks were not available to measure time accurately. Depending on the height of Pisa Tower any object dropped from the top would take not more than three seconds to touch the ground. He found out another way to measure time.

He took a 22 feet (approx. 670 cm) long piece of teakwood. After making a deep groove in the wood, it was bent slightly. This groove was chiseled to make it smooth and frictionless, so that the ball placed in the groove could slowly move towards the ground. To measure time he had placed a pierced bucket with water falling drop by drop. He collected this water and measured time. To

find out the effect of gravity, he performed this experiment and made some unique observations. He derived his laws of motion through this experiment. He proved the mathematical laws experimentally. He further derived new laws of motion from it which were different from the established laws.

The orthodox professors and religious leaders of that time did not accept his findings. They believed in the saying 'old is gold'. The few who opposed him made efforts to relieve him from Pisa University. Finally, fed up with the opposition, he resigned from his post in 1592. For someone who spoke the truth and unfaltering in his belief, Galileo had to face a few tough days. With discontinuation of his income he faced a crisis. In fact, his intellectual prowess made many people jealous of him and some also developed an inferiority complex. Others were not ready for change. Thus, Galileo got isolated. After resigning from Pisa, he went to his father's house in Florence. But, his father met an untimely death. As the eldest son, the responsibility of seven brothers and sisters fell on him. Despite this he did not waver from his charted path.

Meanwhile, he got a job as professor of mathematics at Padua University in Venice. His salary was also good. Gradually his difficulties ceased. He stayed there for 18 years and it was a period of relative prosperity and fame. Students from all over the world came to study under him. The future German emperor too, came to study here.

He got interested in Astronomy after coming to Venice. In 1609, he got the news that some scientist in Holland had designed a telescope with the help of a lens. He, too, designed his own telescope. The news of his telescope spread far and wide and people started flocking to see it. On the request of the royalty of Venice, he agreed to publicly display his telescope.

Galileo watching the skies with the Telescope

For observing the sky with the telescope, he placed his telescope on the dome of the town's tallest church, and observed the ships plying in the far sea. According to Galileo, an object which was 50 miles away could be seen just five miles away through the telescope. The Prince of Venice requested Galileo for a telescope for the army and the navy. He accepted the offer and gained respect and an increase in salary.

Galileo observed the sky with his telescope. He first observed the moon and became the first human being to do so. Viewing the moon he came to realize that the moon was not flat, but comprised of mountains and valleys. He also measured the height of mountains on the moon. He noted that the planets, like the stars, did not shine on their own but depended on some outside source for light. He also took note of the fact that stars are sources of light, which emit light rays in all directions. He observed the sky and noted that the galaxy is clusters of stars. He focused his telescope on Jupiter and first found out its four moons. He also found out that the earth reflects the Sun's light. Someone who views the earth from the

moon will find the same characteristics as in the moon when one views it from the earth. He opposed the traditional belief and announced that earth was not the centre of the universe. Scholars and religious leaders were furious and rained insults at him. Thus, all his new findings gave him fame as well as foes.

Galileo had a well-paid, permanent job in Venice. But his heart cried out for Florence, his native land. He began efforts to return to Florence. He thought of penning down his discoveries. His efforts bore fruit when the Grand Duke appointed him as the duke's mathematical advisor. In 1611, he left Venice for Florence. His troubles began soon after he set foot here. Florence was the seat of the Pope's decree. Galileo backed his discoveries with Copernicus' theories. When Galileo visited the Pope in Rome, he was deceived into accepting the allegiance. He was banned from spreading Copernicus' beliefs opposing religious order among the people.

Galileo was now a broken man. In 1618 he had proposed a theory on the flood and ebb-tides of the seas. This theory was also on the lines of Copernicus' beliefs. It was believed then that the ebb and flood tide occurred according to the wishes of the Almighty. Galileo asked for permission to publish a book based on science. After a long delay he was granted permission. When the book was published and reached the Pope, he declared it against religion and accused Galileo of getting it printed through illegal means. The book was banned. He was charged with fraud. Suddenly, everything seemed to go against him.

In 1634, at the age of 70 Galileo appeared in court. He was forced to accept the verdict and he stated, "I am now giving up my untruthful theories." He also said that, "from now onwards I will not spread these false theories." The experts in the court declared "Earth is the centre of the universe not the Sun." He was sentenced to solitary confinement for the rest of his life. He spent the last eight

years of his life in seclusion. Prior permission was needed for any person to meet him. Galileo was worn down both mentally and physically. Finally, on January 6, 1642, this great thinker and researcher breathed his last, ending his suffering.

25

Johannes Kepler

About five centuries ago, the man who propounded the Helio-centric (the sun at the centre) planetary motion theory – Johannes Kepler was born in Wiel der Stadt, Wurtemberg, Germany in 1571. Students of astronomy still study his theory. His father was a mercenary soldier and his mother was a daughter of an innkeeper. When he was four years old, a bout of smallpox weakened his eyesight and affected his health. Despite such difficulties, young Johannes Kepler was a bright and intelligent boy.

Kepler's early education was in a local school and then at a nearby seminary for aspiring priesthood. He went on to enrol on a scholarship at the local University of Tübingen, then (as now) a bastion of Lutheran orthodoxy and in 1591, obtained master's degree in theology. His favourite subjects were mathematics and science. During his study he was introduced to Copernicus' theories. The way planets revolve round the Sun interested him. He now gave up his ambition of becoming a priest.

In 1594, at the age of 23, he was appointed as lecturer of mathematics at Grates University. He then married a girl from a rich family. Things started looking up and it seemed he had found a definite direction in life. Kepler belonged to the Protestant faith. Communal disturbances and strife forced him to abandon Grates University in 1597. This great mathematician and scientist had a liking for theology. He linked all of life's incidents with it. He believed that he had no faith in astrology.

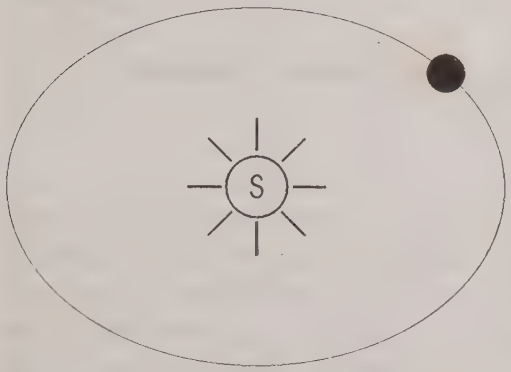
When Kepler left Grates University, it so happened that Denmark's famous astronomer Tycho Brahe had settled in Prague after being banished from his country. Brahe was opposed to the Copernicus' theories. He believed more in the Almighty's universal principles. Brahe's observations regarding the stars were aplenty. Kepler got an opportunity to work with Brahe. Brahe appointed Kepler as his assistant and torchbearer. Kepler then firmly believed that the Sun was the centre of the universe and not the earth.

In 1601 AD, Tycho Brahe passed away, but Kepler's planetary calculations continued. After analyzing Brahe's works Kepler came to certain conclusions regarding the motion of planets, which were noteworthy. Thus, the geo-centric (earth at the centre) planetary observations that Ptolemy made were focussed on to Copernicus' observations that planets revolved round the Sun in circles. Kepler improved upon this theory and proved that the orbits of planets were not in circles but in flattened circles or ellipses. His important observations came to be recognized as Kepler's laws. Kepler's three laws of planetary motion are as follows:

(1) The orbits of the planets are ellipses, with the Sun at one focus of the ellipse.

(2) The line joining planet to the Sun sweeps out equal areas in equal times as the planet moves around the Sun.

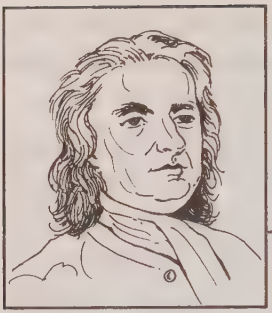
(3) The squares of the periods of any two planets are proportional to the cubes of their mean distance from the Sun.



Kepler concluded further that the Sun has a major influence on the motion of planets. Some magnetic force worked between the Sun and the planets. After almost half a century, Isaac Newton propounded the Laws of Motion and Gravitation. Even today Kepler's and Newton's laws are considered path-breaking.

He had made a deep study of human sight and telescope. This way he laid the foundations for the development of telescopes for the study of celestial bodies.

Regarding Kepler's novel discovery that planets move in elliptical orbits around the Sun, many feel it is incomplete. There is regular change in the planetary motions around the Sun. Through calculations he also concluded how much time celestial bodies take to complete one orbit around the Sun. From this, he concluded that planets closer to the Sun take less time in orbit. It can be said that Johannes Kepler's discoveries would have contributed a great deal to the Laws of Gravitation propounded by Isaac Newton. 12 years before Isaac Newton was born, this great scientist died in 1630 of fever at Regensburg at the age of 60.



26

Sir Isaac Newton

World famous scientist Sir Isaac Newton was born at Woolsthorpe Manor in Lincolnshire, England, on Christmas day in 1642. As a baby Isaac was a weakling. Having lost his father before his birth, he was born prematurely. The widowed mother lost all hope of the baby's survival. She never had the faintest idea that this baby would one day not only become one of the world's greatest scientists, but also live long.

When Newton was two years old, his mother remarried. He was then shifted to his grandmother's house and she raised him. This young boy engaged himself in some activity or other. He made a sundial in stone. Besides, he made a watch that ran on water and a model of a windmill. The sun clock he made is on display at London's Royal Museum. He also loved reading.

When he was 14 years old, his mother was once again widowed. He started living with his mother now, and started helping her at their farm. Soon his mother realized that as he approached adulthood his interest in farming was waning. At home he would daydream. He began making models using wood. Finally, his mother agreed to send him to college. Isaac was thrilled. At the age of 18, Newton joined the famous Trinity College at Cambridge. After four years, in 1665, he gained his graduate degree in mathematics from Cambridge University. In college his mathematics professor Isaac Barrow recognized his potential and started encouraging and guiding him and later, became his friend.

At that time the plague epidemic raged all over England. About ten per cent of the country's population died of this epidemic. Schools and colleges were closed. Cambridge University too was closed. Newton was back at his mother's farm. Till the time the university reopened after a year and half, Newton stayed with his mother. The time he spent here was the most productive period of his life. His greatest discoveries were made during this time (1665–66) and is also known as miraculous year in Newton's life. He laid the foundations of the calculus and the laws of motion. He also examined the elements of circular motion and applied his analysis to the moon and other planets. Seeing a falling apple gave him insight into the law of universal gravitation. The seeds of his famous work on optics were also laid then. He later elaborated these and were recognized as the world's greatest discoveries of those times.

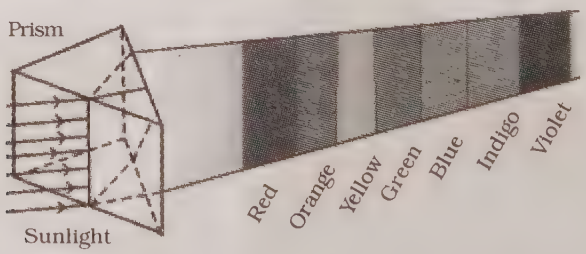
White light is made up of seven colours.

In 1667, when the university reopened, Newton was appointed lecturer. He made quick progress and in 1669, at the age of 26, he was appointed Lucasian Professor of mathematics in place of Professor Isaac Barrow.

For long Newton was involved in the research on light. Newton's first work at Trinity College was in optics. While at home, Newton had conducted many experiments in his darkened room with a glass prism. When he let in a chink of daylight between the curtains or a ray of white light passed through a prism, it was refracted.

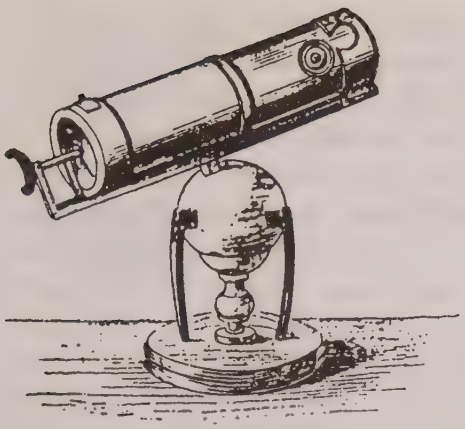
But different parts of the beam were refracted in different amounts, and the beam emerged split into several colours. The colours were same and in the same order, as they appeared in the rainbow: red, orange, yellow, green, blue, indigo, violet. Newton came to the conclusion that white light could be split up by the prism into a spectrum of merging colours in the sequence red, orange, yellow, green, blue, indigo, violet, and these colours, when recombined by the prism, formed white light. Newton called it a crucial experiment or Experiment Crucis.

He also designed and constructed the reflecting telescope. This telescope had an image that was not formed by a lens, but by a concave mirror. James Gregory had proposed such use of a concave mirror earlier, but Newton



Sunlight passing through a glass prism gets refracted into seven colours.

was the first to make such an instrument. The telescope aroused more interest than his lectures because here was something that could be seen, handled and tested. The Royal Society, heard tales of this 'Wondrous Instrument' and in 1671, it caused such a sensation that it was demonstrated to King Charles II, on special request. The



Newton's reflecting telescope

small telescope, which performed so well, aroused great interest at the Royal Society. As a result, Newton was elected a member of the Royal Society, to which he donated the reflecting telescope. The diameter of the mirror was one inch. One such reflecting telescope is installed at the California Institute of Technology's Mount Palomar Observatory. Its diameter is about 515 cm.

His initial research papers focused on light. Many scholars opposed these vehemently, though some praised it. He had replied to Christiaan Huygens and Robert Hookes' criticisms. By then a popular figure, Newton, who was psychologically incapable of accepting criticism, was so upset that he swore not to publish any scientific work. Now he quietly worked to develop the theoretical principles underlying his experimental works. Besides, he represented the university in parliament.

In 1664, the famous astronomer Edmund Halley visited Newton. He had come to discuss Kepler's laws on the motion of planets. Halley came to realize that Newton had laid down the basic laws of mechanics. He had formulated the laws of motion and the laws of gravitation through his calculations and conclusions. At Halley's urging, Newton reproduced the proofs and expanded them into a paper. Halley at once recognized the importance of what Newton had done and also, realized that he was dealing with a genius. He persuaded Newton to publish his works and results. He volunteered to bear all the production cost.

Halley encouraged Newton to write a full treatise of his new physics and its application to astronomy. In 1687, Newton finally published the *'Philosophiae Naturalis Principia Mathematica'* (The Mathematical Principles of Natural Philosophy) in three volumes in Latin, which caused a sensation. Newton became internationally famous. Though his concept of 'force' was not generally accepted, leading scientists of those days soon recognized him as a worthy successor of Galileo and Descartes. The 'Principia' is still considered as the greatest scientific book ever written. His third law of motion – that action and reaction are equal and opposite has done wonders. Present day rockets and jet planes run on this principle.

In 1698, Newton was appointed as the Master of the Mint after working as the Warden of the Mint from 1696. He held this prestigious position and made many important changes to prevent manufacturing of counterfeit coins. In 1701, he resigned his fellowship and professorship at Trinity College.

In 1703, Newton was elected president of the Royal Society and remained on this post till his death. In 1705, Queen Anne honoured him by conferring on him the title of 'Sir'. He died on March 20, 1727 at the ripe old age of 85. This great scientist was laid to rest with other eminent personalities at Westminster Abbey.

27

Henry Cavendish

Known as the discoverer of hydrogen, Henry Cavendish, was born in Nice in France on October 10, 1731. He was a rich man in his time. But his lifestyle and dressing remained that of a common man. He wore mended clothes and wornout shoes. He was a happy, carefree and reserved person. In the 14th century, his grandfather and great grandfather held important positions. He was a nobleman from an aristocratic family. His ancestors included a Lord and a Chief Justice. His ancestor Thomas Cavendish was a great adventurer. He had sailed around the world with his flotilla of ships. Thus, the entire family of Henry held a leading position in the country.

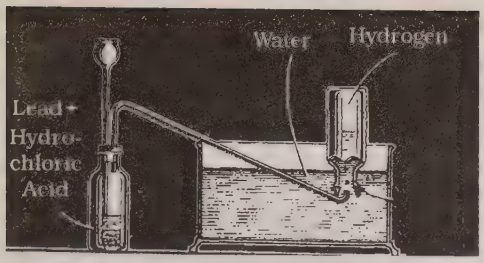
Henry was elder and Fredrick, the younger of the two sons of Lord Charles and Lady N Cavendish. His mother died when Fredrick was born while Henry was just two years old. Henry's father was a well-known scientist and a Fellow of the Royal Society of London. He invented the minimum and maximum temperature thermometers. For his invention he received the prestigious Copley Medal from the Royal Society.

In 1742, at the age of 11, Henry was admitted to the boarding school at Hackney. He then studied for four years (1749–53) at Peter House College, Cambridge. Religion, religious teaching and religious groups never interested him. But, it was compulsory to take up religious study to obtain a graduate degree. Therefore, he left the university without a degree.

Henry and Fredrick stayed in London for some time. They moved to Paris to study physics and mathematics. During their study they received a limited, but sufficient pocket money. When Henry Cavendish was 40, his father died leaving him a fortune as inheritance. Since then he never felt dearth of money. He received good education and his economic condition too, was fine. He felt uncomfortable in the company of women and was also called misogynist. Even for the maidservants he left written instructions. He had few friends. Besides, he spoke very little. He spent little time in activities other than that related to science. He would ask his banker/investor to take their own decision rather than consult him. He lived detached from this world, his only link being the Royal Society of London. In 1760, at the age of 29, he was appointed the Fellow of the Royal Society. Now, he regularly visited the Fellow club to have food.

At that time, science had yet to reveal the mystery of fire, its significance and its safety. Two German scientists John Bayer and his student George Ernest Stahl had given some insight on fire. Though it was generally accepted it had some inherent flaws. Priestley, the discoverer of oxygen, too, at that time accepted Bayer's conclusions regarding fire. According to Flogisten's theory, all inflammable substances contain at least two elements: the ash of the substance and the inflammable element Flogisten. When a substance burns, the inflammable element is released. When this element stops coming out, the fire is extinguished. Till now, nobody had tried to analyse Flogisten. Cavendish decided to take up the challenge.

Henry Cavendish studied the subject extensively in the library. Meanwhile, he learnt that Parcelsus and Yan Von Helmont had discovered an inflammable gas. For this they had placed some iron pieces in sulphuric acid. Some bubbles surfaced on the iron pieces. The gas produced

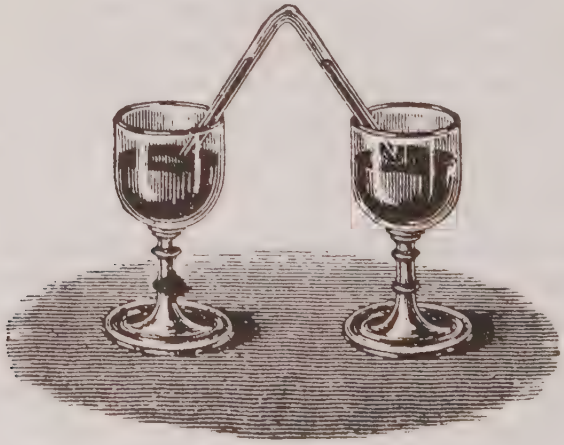


Producing Hydrogen in Laboratory

through this process was inflammable. They did not work any further on this subject. Cavendish thought that this inflammable gas might be Flogisten. He had set up a small laboratory in his house. He collected some iron, lead and tin pieces, besides hydrochloric acid and sulphuric acid. He poured equal quantities of sulphuric acid in three equal containers and did the same with the hydrochloric acid. He then put an equal number of iron pieces in both the acids. He did the same with the lead and tin pieces producing hydrogen. As a result of the chemical process some bubbles surfaced. He collected the gas bubbles in separate balloons. He noticed that all the balloons contained samples of inflammable gases and they all produced similar blue flame. On further observation he found that the gases weighed the same and the volume of inflammable gas produced was proportionate to the metal pieces. He concluded that he had succeeded in separating Flogisten. He announced his findings at a meeting of intellectuals of the Royal Society in 1766. Nobody doubted the veracity of his research.

Today, it might seem odd how intellectuals of that time accepted the gas as Flogisten. Cavendish, was no doubt a genius. But some time later, French scientist Lavoisier rejected Cavendish's theory about Flogisten and declared that the combustible gas was not Flogisten but hydrogen. The discovery of hydrogen created sensation among scientists and the public. The fact that hydrogen was lightweight and inflammable and could be produced easily at home attracted the attention of many. As a result, many accidents occurred and some people lost their lives too. Mixture of hydrogen and oxygen can result in an explosion.

In 1783, a hydrogen-filled balloon was flown. Earlier, in 1781, an Italian based in England had publicly demonstrated that hydrogen filled soap bubbles would move upwards. Even before this, a balloon prepared from cloth with paper lining was filled with hot air and flown. A French scientist Jacques Charlie had successfully flown a hydrogen-filled balloon to some height and distance. Of course, no humans travelled in it. When this balloon landed 15 miles away in a farm, the frightened farmers destroyed it. In 1775, a hydrogen-filled balloon carrying humans was flown. But it had suddenly burst killing all the travellers. This incident put a full stop to this activity, until a gigantic balloon was flown in Hindenburg, Germany, a century and half later, in 1937. It crossed the Atlantic Ocean many a time. During one such flight with 36 passengers, the balloon filled with 90 lakh cubic feet hydrogen, burst while it cleared the sea and was passing through Lake Hurst area in New Jersey. All the passengers died in the accident.



The simple arrangement used by Henry Cavendish in which an electric spark is passed through the mixture of oxygen and nitrogen placed in a tube resulting in their blending.

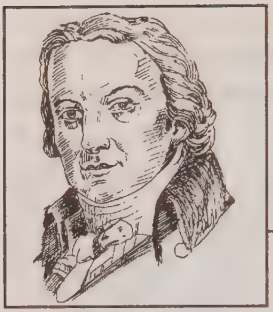
The Royal Society had noted such incidents in which dew was formed with the burning of hydrogen. Priestley had described the blast produced by the fusion of hydrogen and air in a glass jar.

In 1784, after many experiments, Cavendish had announced that when oxygen and hydrogen combined, it produced water. Thus, he established that water is not an element but a combination of two colourless gases. Cavendish announced his 'Experiments on Air' at the Royal Society. He also said that the air we breathe contains 20 per cent oxygen. He concluded that when there is a spark in the atmosphere, there is a synthesis of oxygen and nitrogen. Thus, lightning in the sky brings together oxygen and nitrogen.

Cavendish lived a lonely life and in 1810, at the time of his death when he was 79, there was no one around to take his care. His funeral was carried out at Derby in England. The local church also set up a memorial in his name. The man who never believed in sect or religion had a memorial in his name.

In his will he had declared his entire wealth in his cousin's name.

One who spent his entire life in pursuing science, Cavendish did not leave any money for the development of science. But his inheritor set up a chain of Cavendish laboratories to show his indebtedness to science. In 1897, the great scientist J J Thomson discovered the electron at one of the laboratories. The laboratories also produced many Nobel laureates.



28

Edward Jenner

Dr Edward Jenner, the inventor of the smallpox vaccine was born on May 17, 1749 in Gloucestershire, England. His father was a vicar. Edward was admitted to the local primary school, where he turned out to be a good student especially interested in biology. Gradually, he began studying to become a doctor. At that time it was customary for a medical student to assist an experienced doctor and seek his guidance. He sought training under the experienced surgeon Dr Daniel Ludlow. At 21, Jenner joined the St George Hospital in London to undergo training under the great surgeon and anatomist Dr John Hunter.

It was a time when the field of medicine was in its nascent stage. Doctors experimented with herbs and used them to cure a disease. When an epidemic struck any region, millions of people lost their lives. Between the period 1700–1800, in Europe alone, 60 million people succumbed to various diseases. People considered such contagious disease as the Lord's wrath or curse.

In 1721, smallpox had infected almost half the population of Boston in USA, 10 per cent of whom lost their lives. Today, this disease has been eradicated from the face of the earth. The vaccine has played an important role in controlling and curbing this disease. All credit goes to Jenner for discovering the smallpox vaccine.

Dr John Hunter of the St George Hospital was an inquisitive and restless soul. He would conduct various experiments, which he would try on himself first.

Unfortunately, he became a victim of an incurable disease, which cut short his life. His students underwent the same kind of rigour. Hunter became Jenner's lifelong friend and guide. After graduating from St George Hospital, on the advice of Hunter, Jenner returned to Gloucestershire to practice medicine. Hunter and Jenner continued their correspondence for long. Hunter believed that the rural-bred Jenner would be more comfortable working in a rural area than an urban set-up.

Modern medicines were still a far cry in those times. Doctors prescribed herbs and people preferred homemade remedies to combat diseases. They knew that some plants and vegetables had miraculous healing powers. Degetelis was considered to be a vital medicine for heart-related diseases. Like India, local remedies were sought there.

Some diseases attack a person once in a lifetime, for example, German Measles. Parents would feel relieved if this disease attacked their daughters at a young age, since it would create complications at a later age. Once this disease attacked at a young age, it would not attack again. Besides, it was easiér to cure this disease when the patient is young.

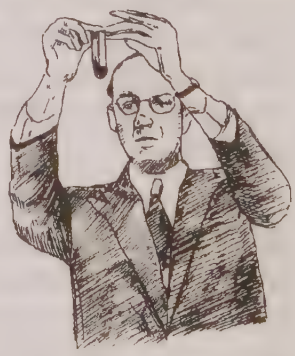
Similar belief prevailed in the case of smallpox. In the East, to escape the curse of smallpox it was a practice to inject the germs of smallpox in the body to weaken its deadly effect. Unfortunately, some lost their lives in the process.

The village folk of Gloucestershire found that a patient of cowpox did not catch smallpox. This disease first attacks cows and cows pass it on to humans. A question invariably comes to our mind: Why only cows and not horses or any other animal? Encouraged by Hunter, Jenner concentrated his research on cowpox. He examined 27 patients suffering from this disease. He published his findings in 1796.

He conducted a unique and bold experiment. After convincing the parents, Jenner injected an eight-year-old boy Jimmy Fipps with lymph from a cowpox vesicle. It made the healthy boy sick. He followed this with injections taken from smallpox pustules. The boy did not develop smallpox.

When Jenner announced his findings, there was upheaval in society. There were some who criticized Jenner for interfering with the natural process of life and some who congratulated him for his achievements. Some even said it was no big achievement and still others tried to imitate him and conducted experiments without proper knowledge, killing patients rather than curing them in the process.

When the dust settled, Jenner detailed his discovery –presenting the world with the smallpox vaccine. The world honoured him and the Parliament conferred Knighthood on him. He was now Sir Edward Jenner. Besides, he was awarded £20,000. Oxford University bestowed on him an honorary degree. The Czar of Russia gifted him a gold ring and Napoleon congratulated him for his path-breaking discovery. A group of Indians based in America honoured him with gifts and publicly lauded his achievement. The world will remain indebted to Jenner for his vaccine that has contributed to a healthy generation. We should always ensure that every healthy child is innoculated for all– smallpox, chickenpox, polio and diphtheria.



The founder of polio vaccine Dr Jonas Salk

Jenner spent his later life at his country house in Gloucestershire. He died in January, 1823. His vaccine has ensured a smallpox-free society. Various

vaccines developed for different diseases have helped children to be resistant to diseases. Dr Jonas Salk is one such precursor to develop the polio vaccine and contribute towards a polio-free world.

29

Amedeo Avogadro

Amedeo Avogadro – the scientist whose genius came to be acknowledged belatedly – was born on June 9, 1776 in Turin, Italy. His father was an advocate and it was almost certain that Amedeo would follow his footsteps. In school, teachers recognized the genius of Amedeo. At 16, he became a graduate and by the age of 20, he had a doctorate in Church Laws.

He then started his practice as an advocate by assisting his father. But within three years he bid adieu to this profession and turned to mathematics, physics and chemistry. He also researched on electricity. His teachers came to recognize him for his work. At the age of 33, he was appointed professor of physics at Royal College, Versailles in North Italy. He then started concentrating on teaching and research. In 1811, at the age of 35, he published a research article on atom in a French journal, The Physics. Ironically, the article, which is recognized as an important document today in the science world, failed to draw attention for nearly fifty years.

He spent his entire life in teaching and research. During his university education, civil war and revolt raged

in Italy. Education too was affected time and again, what with frequent change of leadership, educational institutions and colleges were shut and reopened irregularly. During the years 1820–50, he worked as professor of physics at Turin University. The authorities closed the university time and again. This affected education due to the fragile situation in the country.

Even at the time of his death in 1856, the world failed to recognize the worth of the work of this 80-year-old scientist. Even on the domestic front life was not very different. Normally, scientists are very outspoken. They are ever ready to make their findings public and discuss them. They wish that knowledge and information should not remain confined to a single person or country.

Today, things are different. Scientists should know one more international language besides their own. In our

The size of a water drop

country too, to move forward in the field of research, besides English, it is necessary to have some working knowledge of French or German.

When Avogadro published his papers in 1811, the subject he discussed was totally unknown to people. He clarified the difference between an atom and a molecule. It was a very important paper for physicists and chemists. But this paper published in French went unnoticed. This also means that science received a setback of 50 years.

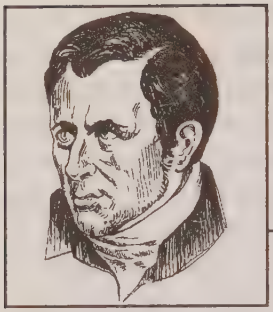
Water is a compound of hydrogen and oxygen. It is made up of two atoms of hydrogen and one of oxygen, making it H_2O. These atoms and molecules are minute. Modern scientists have found out the technique to count the atoms. Years ago, Avogadro put forward the hypothesis that equal volumes of all gases, under identical conditions of temperatures and pressure, contain equal number of molecules. This is known as Avogadro's law principle.

John Dalton an English chemist, considered the father of atomic science, thought water to be HO. But today it is a known fact that water is H_2O and not HO.

In 1808, the famous French scientist Joseph Gay-Lussac conducted some experiments whose results opposed Dalton's theory. Actually both were correct. In his research paper of 1811, Avogadro shed light on this matter. We realize the folly today, of ignoring his findings.

In 1860, a science conference was organized in Germany, whose aim was to find answers to many questions in chemistry. Many views were put forward and discussions held. Italian chemist Cannizzaro reestablished Avogadro's theory and clarified that it was not necessary for two different atoms to create a molecule. For example, the oxygen molecule contains two similar atoms. Though no conclusion was arrived at, Cannizzaro remained undeterred. He kept advocating Avogadro's theory through various articles. Finally, it was accepted that the formula for water is H_2O.

In 1911, scientists celebrated the centenary of Avogadro's laws. They assembled in Turin and paid homage to him. Thus, the great scientist, who remained quite unknown during his lifetime, came to be known as the torchbearer of research work a century after his death.



30

Sir Humphry Davy

Humphry Davy was born in Penzance village, Cornwall, South Western part of England, on December 17, 1778. His poor father would make a living out of wood crafting, carpentry and farming. Humphry had his schooling in Penzance and later, he had higher education from nearby Truro. Soon after completion of his primary education, Davy went to a local chemist Thomas Beddoes of Bristol, who trained him in making drugs. Beddoes had a personal library where Davy would spend his free time, reading books. He cultivated great interest in reading here and specifically, in chemistry. He also experimented on the basis of the books that he had read then.

Due to his thirst for reading and experimenting, he came in touch with Watt Jr., the son of Sir James Watt, the famous engineer and inventor. He introduced Davy to the president of The Royal Society, Dr Gilbert. Impressed by Davy's interest and dedication, Gilbert wrote a recommendation letter to the founder of the then newly established Medical Pneumatic Institution. This institute conducted research studies on the use of different gases in the field of medicine. He was immediately employed here. Not only that, Davy who had not even seen the University, was lucky enough to get work of his choice. It was here that he worked hard and sincerely to become the youngest head of the institution at the age of 20.

Davy, who had come up in life the hard way, was rather, whimsical in nature. His work led him to propose that electrical forces hold the elements of a chemical compound together. Davy must have known of Lavoisier's suggestion that the alkali earths were oxides of unknown metals. At first, he tried to separate the metals by electrolysing aqueous solutions of the alkalis, but this yielded only hydrogen gas. The important discovery he made in the year 1799 brought him fame from all over the world. He prepared Nitrous Oxide gas in his laboratory. This gas is used even today as anaesthesia for making patients unconscious and then, conduct surgical operations. The operation thus performed is painless and easy to conduct for the surgeon, as the patient remains unconscious throughout the period of operation. However, in his lifetime, this discovery was not put to use. It was in the year 1844 that an American doctor used this medicine to extract his decayed tooth painlessly. The medicine numbed the area near the tooth so that the operation could be conducted without pain and with least effort.

There occurred another interesting incident when he discovered this medicine. He drank it instead of smelling it and he had an intoxicating feeling. He would laugh without any rhyme or reason and that is the reason why it was called laughing gas. Davy attained fame due to this very interesting discovery.

Around this period, Count Rumford, an American scientist, arrived in London and set up the Royal Institute. He extended invitation to Davy for giving lectures in chemistry. Davy had no prior experience as a teacher, yet the manner in which he delivered them and the popularity that he achieved, earned him the title of professor. The reason for this was that he was truly dedicated to his work and studies. He was a very good public speaker too. His easy style of communicating and the manner of

simplifying and putting forth the most complex issues of chemistry impressed the Agricultural Board of the Royal Institute. They requested him to take up the issues relating to agriculture and provide necessary guidance to them.

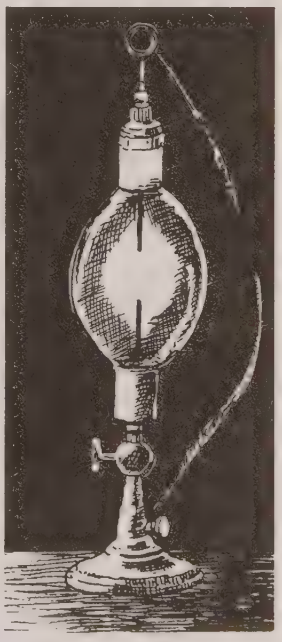
He then spent the next ten years of his life conducting deep research and studies in the field of agriculture. He provided necessary inputs and guidance in this field and developed fertilizers so as to help increase the agricultural production.

Apart from this, he developed electrochemical process in chemistry. Commonly known as caustic soda, a wet piece of sodium hydroxide is placed in a platinum cup. One end of the wire was connected to one terminal of the battery and the other end to a piece of caustic soda. Another wire connected the second terminal of the battery and the platinum cup. This way an electrolytic chemical reaction took place that produced sodium vapour. Today our roads and streets are lit with the help of sodium vapour lamps. He also isolated potassium with the help of electrochemical process. Similarly, he also obtained sodium, magnesium, strontium, calcium, chlorine and barium through this process in the year 1808. Following the same process, Charles Martin in the year 1886, isolated aluminium from aluminium oxide. As part of further development, Davy also invented the arc lamp.

Impressed by the invention of the electrochemical process of separating sodium and potassium and its technique, Napoleon, the French Emperor presented him with the French Institute Medallion. Even as England and France were at war, Davy, at the age of 30, was presented the medallion at a special ceremony. The arc lamp invented lit brighter than any other lamp that was available then. Such arc lamps have applications in the film industry and making of military searchlights.

In 1812, a young man named Michael Faraday came to meet him. He would attend every lecture or speech of his and jot down in his beautiful handwriting. He showed those notes to Davy. Learning of his careful and enthusiastic approach, Davy was impressed and he immediately employed him as an assistant. Another reason was that he had suffered from the blinding effects of the experiments he was conducting in the mines and needed a helping hand. This young man, Faraday later went on to become one of the world's most famous scientists.

The same year, the king of England bestowed him the Knighthood. Three days later, he married Jane Apreece, a rich widow. After a few days, the couple accompanied by Faraday as Davy's assistant and valet went on a world tour to deliver lectures and learn more about the scientific activity that was taking place all over. In Paris, Davy was honoured and made the member of the French Institute. In Italy, he conducted research on the torpedo fish that produced electricity. At Genoa, the famous Italian city, he burnt diamond with the help of arc lamp to prove that it is made of carbon. Visiting Sweden and Germany, he turned back to England and reached there in the year 1815.



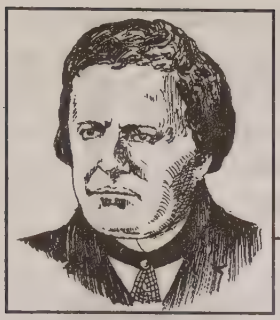
An arc lamp known as the Davy safety lamp

Now he was faced with a very complex problem. He found its solution by conducting a new and useful research for the world. In the coal mines of Newcastle, frequent accidents used to take place. Due to this, many miners lost their lives and production of coal was also affected. The reason for this was the lamp with flame that was taken inside the

mine. The gases present in the mine would catch fire and blasts would occur simultaneously. After in-depth study, Davy invented the now famous lamp known as the Davy safety lamp. To ensure that the heat does not ignite fire, a round wire gauge mesh was placed around the flame. The gases never came in contact with the flame. This way, the number of accidents was reduced and many a lives were saved. This was the period when the battery torch was not yet invented. Davy was so humble that he refused to patent the invention and for the safety of the miner he allowed his invention to be freely used without any charge. The mine owners were happy for this gesture of his and presented him a silver dinner set. As per Davy's will, the silver set was melted on his death and sold. Davy medal was instituted in his memory out of the money collected and is presented every year to scientists of Europe and America who make significant contribution in the field of chemistry.

In 1818, Davy was made the Baronet and honoured. In 1820, he was made the president of the Royal Society. He was not well mannered nor polite due to which he became very unpopular. He earned more enemies than friends and had to finally give up the position.

Finally, in 1829, Sir Humphry Davy died at the age of 48, in Geneva. The inventor of the safety lamp and arc lamp and discoverer of six important chemical elements was honoured as the 'Father of Electrochemical Process'.



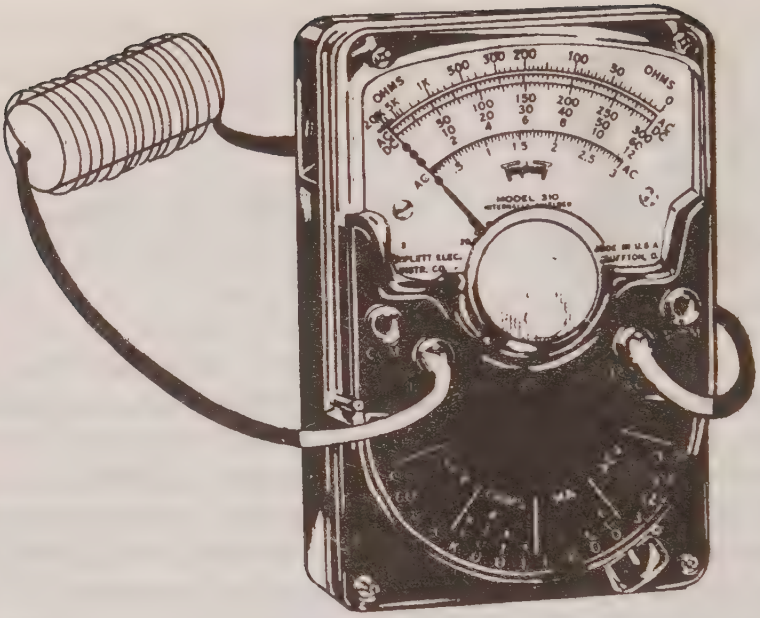
31

Georg Simon Ohm

Georg Simon Ohm was born in South-Eastern Germany on March 16, 1787. His father was a locksmith who also manufactured and repaired guns. Since generations his family was involved in the business and his father inherited the same from his grandfather. He would move all over the cities of Germany and France to earn his living. At 40, he came to settle down in the village of Allergen. For 40 years his father conducted this business. After his arrival here, he got married and had two sons– Georg and Martin. His life took a turn thereafter.

Georg's father was now attracted towards education, particularly in mathematics and science. He became involved in mechanical instruments and conducted research on his own. He began concentrating on mathematics and science. He even went on to cultivate similar interest for the subjects in his two sons. The two sons grew up to graduate in mathematics from the university of Erlangen and later, became professors.

At a young age of 18, Ohm was appointed professor at Swiss Canton in the city of Gottstadt in Berne. The supervisor who scrutinized his application for the job was a bit disappointed when he saw the young man. Ohm's appearance was short and skinny, like a boy. But in a short while, his disappointment vanished. He was thoroughly happy and impressed to find the new professor's depth of knowledge and his simple method of teaching. Ohm also became involved in further studies and research.



Resistance measuring instrument named as ohmmeter in memory of Georg Simon Ohm

Ultimately, after 6 years of extensive research and study, in 1811, Ohm earned the doctorate degree. At that time he felt like joining the armed movement against Napoleon and his army. He left his job and prepared himself to join the army. It was his father who stopped him from taking such a step, making him realise and convince him in a practical way. Thus, he continued to work as a professor.

In 1817, at the age of 30, he got an invitation to join the Jesuit College at Cologne as professor and a departmental head. He happily accepted this position. Here, he taught as well as conducted research. As a result, in 1827, he published a detailed essay based on the research that he had conducted for years. It was one of the foremost researches ever conducted in the field of electricity at that time. Sadly, it did not gain acceptance nor recognition for more than twenty years. Ohm was very disappointed by this. He had proposed certain basic

equations and fundamental principles in the field of electricity that made solving mathematical problems in the field easy. Known as Ohm's law, it is the basic law that every student of physics has to learn and understand. The equation $I = V/R$ was given by him, where I = current, V = electromotive force or voltage and R = resistance.

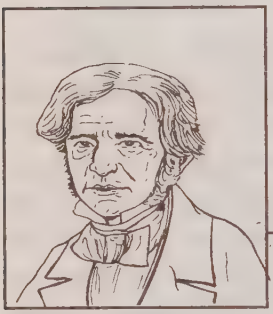
In electricity, Ohm's law experimentally determines the relationship that the amount of steady current through a large number of materials is directly proportional to the potential difference, or voltage across the materials. Alternatively, Ohm's law can be stated as the current I in the conductor equals the potential difference V across the conductor divided by the resistance of the conductor, or simply $I = V/R$, and that the potential difference across a conductor equals the product of the current in the conductor and its resistance, $V = IR$. In a circuit where the potential difference or voltage is constant, the current may be decreased by adding more resistance or increased by removing some resistance.

In 1827, he published a book titled Die galvanische kette mathematics bearbeitet (The Galvanic Circuit Investigated Mathematically). He was under the impression that it would earn him fame and promotion. But it was not to be. The scientific world ignored this remarkable work. Those who read his work found nothing new in it. Ohm was very sentimental. At 40, he resigned from the college. Being jobless, he had to face difficulties. It became so difficult for him that even to buy things of daily use, he had to think twice.

After 6 years, he again began working. No one appreciated his work in Germany, but Britain did return him his dues. The Royal Society of London presented and honoured him with the Copley Medal in 1854.

In the same year (1854), Ohm died at Munich at the age of 67. In 1881, at the Electrical Engineers International

Congress, a resolution was passed that the unit of electrical resistance be called ohm, in his honour. He was finally honoured posthumously for the discovery he made during his lifetime.



32

Michael Faraday

British Chemist and Physicist Michael Faraday was born at Newington, Surrey, now a part of South London on September 22, 1791. His father was a blacksmith who had migrated in search of work from the north of England in 1791. Due to ill health he faced lot of difficulties at work. His mother was a country woman of great calm and wisdom who supported her son emotionally through a difficult childhood. Born in such a family, he had to make do with the available education of alphabets and arithmetic from the Church Sunday school. Physically too, Michael was weak and skinny.

Faraday had three other siblings and all of them could barely be fed as their father was ill and often incapable of doing any work. It is said that Faraday reminisced having lived on one loaf of bread for a week. Belonging to the small Sandemanian sect of the Christian faith, religion provided Faraday spiritual power to survive all adverse situations. This had the single most important effect on him that led him in quest of nature and approach towards life in general.

One kind-hearted distributor of books gave him the job of distributing newspapers and at the age of 13, he

employed him at his shop and also taught him book-binding work. Thus, his going to school came to an abrupt end. Finding time out of his working hours, he began reading books available there thus acquiring knowledge. He came across an exhaustive write-up on electricity in the third edition of *Encyclopaedia Britannica* which opened new vistas for him. This reading brought a great transformation in his life. He was so inspired by it that he went on to purchase necessary items to make a Leyden jar. Using old bottles and lumber, he made this crude electrostatic generator and conducted simple experiments. He also constructed a weak voltaic pile that helped him perform experiments in electrochemistry.

As his interest in science increased, he joined the philosophical society there and began attending lectures, enhancing his knowledge. Around this time Faraday got the opportunity to attend lectures in chemistry by the famous chemist Sir Humphry Davy in the year 1812 at the Royal Institution in London. This was the turning point in his life. He was inspired by the lectures. He copiously took down the notes and prepared a bound volume by hand. He presented it to Sir Humphry Davy, along with an application for a job. Alas, there was no opening! He even wrote a letter to the president of the Royal Society, Joseph Banks, requesting for an odd job there. He received no reply from him. However, Davy did not forget and in 1813, when one of his laboratory assistants was dismissed for misbehaviour, Faraday was immediately called in his place on a salary of a guinea a week. Though the salary was inadequate, he saw bright opportunities coming up his way in the future. Faraday began as Davy's laboratory assistant and learned chemistry under one of the greatest chemists of those times. It is said that Faraday was Davy's greatest discovery. Finally in 1815, he got promoted as assistant and was given the charge of looking after the laboratory instruments.

In 1825, he was promoted as the director of the laboratory. He was now totally engrossed in his scientific pursuits. For several years he experimented the experiments that Sir Davy had performed. In chemistry, he performed electrochemical and metallurgical experiments. He made invaluable contribution in the invention of the famous 'Davy Safety Lamp'.

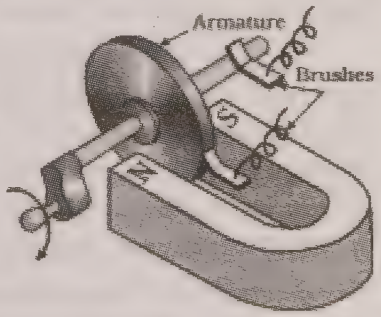
In his electrochemical experiments he reached such levels in analysis that he propounded the famous laws of electrolysis named after him. He gave simple and easy to understand principles on the phenomenon of electrolysis. Faraday's two laws of electrochemistry are : (1) The amount of a substance deposited on each electrode of an electrolytic cell is directly proportional to the quantity of electricity passed through the cell. (2) The quantities of different elements deposited by a given amount of electricity are in the ratio of their chemical equivalent weights. Faraday discovered benzene in 1825. Further, in 1831, he conducted a series of experiments giving clear picture on magnetism and also produced electricity by speedily changing the magnetic forces.

In 1827, he was invited to join as professor of chemistry at the London University College which he modestly turned down. In 1833, he was selected for the Fullerian Professorship of Chemistry at the Royal Institute. Meanwhile, he took up another assignment as part time lecturer at the Woolwich based Royal Military Academy. He even advised and directed other institutions during this period. Due to this shortage of time he had to face difficulties in his research activity.

To ensure that he would not have to face financial difficulties and that he would direct all his energies in research, efforts were made to secure pension–financial assistance from the government. A meeting was arranged with the then Prime Minister Lord Melbourne for this purpose. During the meeting the prime minister passed

some negative remarks. He went on to say that government grants and assistances were a big fraud or a kind of cheating. This was just enough for Faraday. He immediately rejected the idea of seeking assistance and thus, ended their eventful meeting. Some even believed that Faraday was known famously as 'Nature's great refuser'. He refused to take up the University College professorship. He even refused the proposed Knighthood award of the title 'Sir' from the government for which his prior permission was sought. Not only this, he was offered the Presidency not once, but twice by the Royal Society for which he expressed his inability. He had quite a different view about all these awards and honours. In 1824, he was made the Fellow of the Royal Society. After a lot of deliberation and delays he accepted the same.

Finally in 1835, Lord Melbourne was successful in seeking his pardon for the earlier rebuff and granting him government pension. For Faraday now, financial difficulties were a thing of the past. In the meanwhile, due to ill health his research was interrupted. Once again in 1845, he began his research-experiments. But now his efficiency had gone compared to what it was earlier. Prince Albert allotted a house for him in Hampton Court. He spent the rest of his life there.



Generator

His research and inventions were unparalleled, wonderful and invaluable. In the electrochemical experiments he had conducted based on electrolysis, he separated certain elements. On its basis, he defined the unit of electricity – the ampere. By one ampere current we mean the amount of electrical current required to obtain 0.001118 gram of silver when silver nitrate is electrolysed.

On the basis of his experiments on electricity and magnetism, electric motor was invented. This important

research of his established him as a great scientist. In 1820, a famous physicist of Denmark, Hans Christian Oersted announced the discovery that the flow of an electric current through a wire produced a magnetic field around it. André Marie Ampere showed that the magnetic lines of force were circular around the wire.

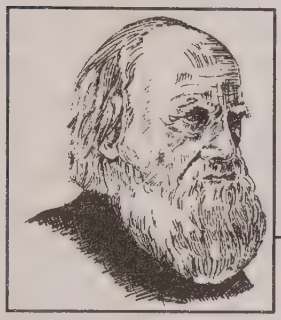
In October 1831, Faraday gave an affirmative answer to this question. Faraday also gave the laws of electric induction. He explained that creating relative motion in magnetic and electric field, magnetic field can be transformed into electric energy. In fact the electric generator designed by Faraday is the original form of today's giant size dynamo.

Faraday made a unique contribution in popularizing science by giving a series of lectures from 1826 at the London based Royal Society for children during Christmas. For years he gave lectures to children providing them an insight on various scientific theories. Even today, eminent scientists are invited to give lectures during the Christmas lecture series. Faraday is considered to be the inventor of electric motor and generator. The unit of capacitance, the farad, is named in honour of Faraday.

He also made contribution in the field of optics. He observed that the path of plane polarised light deviates when passed through a magnetic field and so, light is electromagnetic by nature. Faraday introduced the concept of field (now called classical field) to explain his observation in electromagnetic experiments.

Since 1855, Faraday began to lose his mental abilities. He occasionally experimented on gravitation and other forces and conversion thereof. The Royal Society then refused to publish his negative results that he announced causing lot of disappointment to him. Further, Faraday began to sink into senility or a disease caused due to damage to brain cells in old age. Earlier, he had rejected the Knighthood though he took up the residence at

Hampton Court. He wanted to die as a plain Mr Faraday. On August 25, 1867, this great scientist left for his heavenly abode and would always be remembered as a bright star shining in the sky forever.



33

Charles Darwin

Charles Robert Darwin was born at Shrewsbury, England on February 12, 1809. The famous American President Abraham Lincoln was also born on this day. Charles' father Robert Darwin was a popular doctor and so too was his grandfather Dr Erasmus Darwin, a doctor, a naturalist and a writer of repute. His family was happy, contented and cultured. Charles lost his mother when he was eight years old.

Within the educated and cultured family, Charles was considered very mediocre at studies. The head school teacher would consider him a dull and unintelligent student. However, his father and grandfather had fond hopes for him. His father wished he become a doctor, however his wish was never fulfilled. Many believed that Charles had poor ability to understand or comprehend. Some even considered him to be dumb. In reality, Charles was a very imaginative child. Though not interested in the subjects taught at school, he was interested in the study of nature. He had a very sharp and observant eye.

Darwin was sent to Edinburough University along with his elder brother for higher education. He was again mediocre in his studies but he excelled at the student

debates, particularly on evolution. During the debates he would argue and put across his point forcefully. His ability to analyse and his intelligence were distinguishable from others. Having failed at the university after spending two years, his father felt his dream of seeing him as a doctor vanish fast. Sons of cultured families were in those days expected to study and he was sent to Cambridge. Here, he began studying religion to become a bishop, however he was not at all interested in it. He loved to observe small insects and living organisms. He would never get tired collecting them, observing them and writing about them. At 22, he received a degree in religion, but he never wanted to take up missionary activities. He came in contact with a reputed professor of botany John Henslow, at the University. Henslow gave a recommendation letter and told him to meet Captain Robert Fritzroy of HMS *Beagle*, a 235-ton ocean liner. In this manner Darwin was able to escape from the missionary activities.

HMS *Beagle* was a gigantic government owned ship. It was commissioned to inspect, study and survey the South American coast. Darwin got an offer as Naturalist on the ship. He was supposed to pay for the expenses on board. As he loved the work, his father very reluctantly agreed to pay for the voyage. In 1831, the ship set sail. It was to return within two years but actually returned after five years to England, in the year 1836.

Darwin was a very fine observer and investigator. He would never tire while collecting specimen and writing down his observations in copious notes. He would collect trunk-loads of specimen. For five years he continued the survey of the American coastline. HMS

Giant Tortoise

Beagle finally reached the south western tip about 800 kms away, where the famous natural Galapagos Islands exist. These islands could be termed as nature's biggest laboratory. Here, Darwin was able to discover vital links to the origin of several species. He found unique species of living organisms and also learned about the detailed changes they had undergone during the process of evolution.

Darwin noted that each island had snakes, birds and a variety of other animals. There were dissimilarities among the same species also. One of the islanders pointing at the tortoise, claimed to even identify the particular island to which it belonged. All these bits of information came in handy later when he conducted indepth research.

Darwin read a book by Thomas Malthus 'Essay On Population', which was published in 1838, that cleared his doubts. During the voyage, he had observed and collected several species of plants and living organisms. He had seen and collected fossils too. All this was very useful for his research later. He was certain that be it animals or mankind, all had to fight for food, survival and evolution into further species while adapting to the environment. 20 years after the historic voyage and extensive studies, he arrived at some conclusions. He concluded that changes taking place within our body persist only because they are useful. Useless parts in our body get destroyed. This is how different species evolve and earlier ones become extinct.

In 1858, Malaya's famous naturalist Alfred Wallace published an essay: 'What are the principles of nature that control the changes in living organisms?' This essay had many findings and thoughts common to those of Darwin. Friends advised Darwin to publish his findings too. It was then that he decided to write, print and publish his thoughts, analysis and conclusions and present them to the world. In July 1858, a copy each of Wallace's work

and Darwin's essay separately reached The Linian Society at London and were read by its members. The following year Darwin's book 'Origin of Species' was published. Darwin had attempted to explain the principles of evolution. However, the book generated controversy that went on for a long time. Many works criticising Darwin's theory were published. In one particular essay, a priest of Oxford criticised Darwin's theory.

Darwin was unwell by the time he returned to England. He suffered from nagging headache and fits. At 70, he wanted to go on a sea expedition, but lacked courage. He had married Emma Wedgewood, his cousin in 1839 and settled down in a small village near Kent. He never had to struggle for a livelihood. He spent the rest of his life experimenting in his laboratory classifying the specimen he had collected, in gardening and study. He was cheerful and very popular due to his nature.

This great and famous nature lover, father of the Evolution theory, died on April 16, 1882 at 72. His grave is located next to the famous physicist and mathematician Isaac Newton in the Westminster Abbey. England and the world honoured him this way. It can be said that if he were to visit the Galapagos Islands today, he would feel sad because he would find many unique species extinct, which he had seen in the 1830's trip. Giant tortoises and certain species of monkeys are hard to find. Large aerodromes have been constructed on these islands. Aircraft noise pollution has suppressed the sweet chatter of birds forever. Human interference and the so-called modern cultures have contributed in permanently destroying nature.

34

Louis Pasteur

Louis Pasteur was born at Dole, a small village in the eastern part of France, in the chilly days of the year 1822. His father was in the army. After defeat of Napoleon's army, he returned to Dole. He opened a tannery there. After the birth of Louis the family moved to Arbois in the grapes growing region. His father Jean Joseph was very strong and hardworking. Even though he had not attended any school, he had high regards for educated and intelligent persons. He had great ambition of educating his son. He wished his son to study and become a teacher.

Louis was admitted to the local village primary school. He was an average student. During that time, whenever any one suffered from rabid dog bite, he was taken to an ironsmith. The ironsmith would heat an iron rod till it became red hot. It was then inserted in the wound where the rabid dog had bit. If the person was lucky, he would survive or else would die. Louis had seen this treatment since he was nine years of age. His heart would sink at the sight of it. He always felt like finding an alternative treatment.

Louis' father knew two famous personalities of the village–one a doctor and the other, a historian, D More. Louis' father and D More inspired patriotism in him. 15-year-old Louis was attracted to line drawing hobby. He was quite successful at it. Some of his drawings were later framed and hung at the Pasteur Institute.

A local secondary school teacher had noted Pasteur's ability and predicted that he would become a good teacher. Meanwhile, Pasteur got admission in the science department of the local institute for training teachers. But he did not join the institute, as he was not mentally prepared. During this period, he took keen interest in physics, chemistry and mathematics.

Pasteur wanted to be a good teacher. When he excelled in his class at the preliminaries in physics and chemistry, he felt very happy. He took up research work rather than taking up a teaching career.

Pasteur went to the Ecole Normale Superieure, a University in Paris where he studied crystals. Pasteur had then heard lectures on chemistry by the famous chemical researcher and discoverer of bromine, Antione J Balard. Like Benjamin Franklin, Balard also believed that scientific research could be carried out in a small laboratory. Balard had set up a laboratory for this purpose. When he saw Pasteur, he was impressed by him. He invited Pasteur to assist him at his laboratory. Pasteur happily took up the invitation and joined Balard in his research work. Here, he could continue the research on the microscopic tartaric acid crystals. Balard sent the research finding of Pasteur to Jeane Baptiste Biot, the famous French physicist. He checked the papers and sent them to the French Science Academy for further evaluation.

In 1848, Pasteur was appointed teacher at the secondary school at Dijon in face of strong opposition from Balard and Professor Biot. Pasteur's friends and well wishers stepped up pressure on the education ministry. Due to this, Pasteur was appointed as the working professor at Chemistry Department of the Strasbourg University. At the age of 26 years in the year 1849, he married Marie Laurent, the 22-year-old daughter of the university rector. Marie was a good wife as well as a very good co-worker in his research work.

Pasteur's preliminary experiments were on the crystals. His study clearly identified two types of optically active crystals– producing equal and opposite rotation of polarized light. His other important study was about fermentation or food getting sour and having bad smell. This process is due to microorganisms which he clarified. This process is very useful sometimes, while at other times, it spoils and turns to waste the food products. Due to this discovery of Pasteur, the winemakers of France who manufactured wine from grapes were immensely benefited. After extensive study he discovered that microorganisms are responsible for the fermentation process. It is possible to control this process in order to obtain an appropriate resultant benefit from the same.

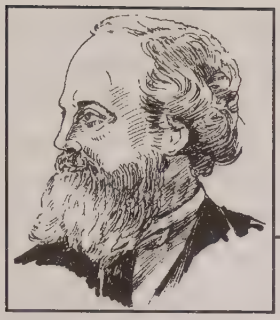
Pasteur in his laboratory

The second result of this study was of ensuring milk remaining fresh for longer duration by a process now called Pasteurisation. This required milk to be heated to a certain temperature and then cooling it, in order to kill the harmful bacteria. Pasteur was honoured for his work and is known as the 'Father of Pasteurisation'. Disease that had entered in the rearing stage of the silkworms affected the production of silk in France. Pasteur undertook study and helped eliminate the same thus saving the industry from destruction. He identified the microscopic organisms responsible for the spreading of disease. In this way he freed mankind from many diseases caused by microorganisms. The bite of a rabid dog and the disease rabies caused due to it was extensively studied by Pasteur and he finally invented a vaccine for its cure. Known as

cure for hydrophobia, a significant achievement then, got him name and fame throughout the world.

He had to face tremendous difficulties and misfortune in his personal life. Jenny, his first daughter died at an early age of 9 years. Again in 1865, his 2-year-old daughter Camilla died after a short illness. In 1866, his 12-year-old son Sybil died of typhoid. When France and Germany were at war in 1871, his son Jeane Baptiste of 20, was declared lost during the action. Pasteur left all his works and went out in search of his lost son. Finally, by God's grace, Baptiste returned home with injury. He started recovering slowly. Pasteur was very angry with the Germans. Years later, the German government wanted to honour him by presenting him a medal for his achievements. Pasteur however, did not accept it.

On September 28, 1895, Louis Pasteur died leaving the world with memories of his great achievements like the Anti-Rabies Vaccine, Pasteurisation and the path that he found to eliminate diseases.



35

James Clerk Maxwell

The pioneer of electromagnetism and contributor to the kinetic theory of gases James Clerk Maxwell, was born on November 13, 1831 at Edinburgh, Scotland. He was from a rich, famous and landowning family. This family had many a famous and promising personalities who brought laurels and honour to it. James spent his childhood in the rural areas. His father had studied law but never practiced. He was interested in educating his son and maintaining the family property. Little James had the hobby of dismantling mechanical toys and understanding their mechanism carefully. He would open up newly acquired toys and fix them again. He had a very curious and sharp mind.

He lost his mother when he was 9 years. His father took up the twin responsibilities of a mother and father in bringing up James then. At ten, James was admitted at the Edinburgh Academy. His father bought him specially stitched clothes and shoes. Other students at the academy would laugh and poke fun at him because of his old-fashioned dress. But soon the students began respecting him for his intelligence and knowledge. They found him very moody.

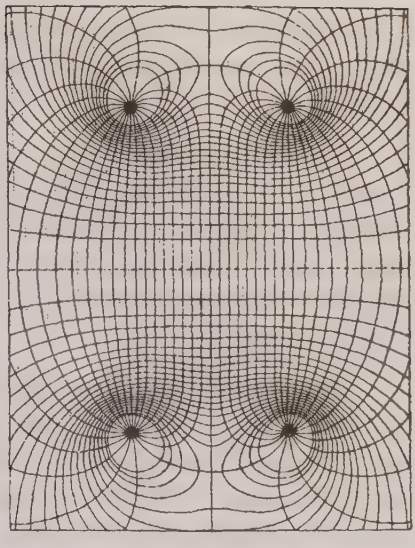
At 16, Maxwell entered the Edinburgh University. His excellence in mathematics astonished everyone. He began experimenting in science. He also wrote poetry, but it was not of high standard. Yet, he continued writing poems all his life.

In 1850, he entered Cambridge University for higher studies in mathematics. He topped at all examinations in mathematics. Mathematics competition was held every year for clever students. To ensure success at the examinations, he was put under William Hopkins' guidance. Maxwell stood second at the examinations. In 1854, Maxwell graduated from college in mathematics. For higher studies, he joined the Trinity College, Cambridge. Here he conducted many experiments on colours and their mixtures. He created a colourful top indicating primary colours–red, green and blue and other colours by mixing them in proper proportions. He even published a paper on this. The colours we see on our Television sets are based on the principles put forth by Maxwell. He was awarded the Rumsford Medal for this.

Around this time, his father was not keeping well. He planned to go to his father and take his care, returning from Edinburgh. Meanwhile, he got appointed as a professor at Marischal College, Aberdeen. But before he could join the college, his dear father died. After some time, he met the daughter of the college principal and soon married her. Now, Maxwell focused his attention on research and experimentation. He had researched on the rings of Saturn and had developed certain mathematical equations with reference to them. Even today, scientists follow the mathematical model he had developed then.

The researches and findings of Maxwell in the fields of electricity and magnetism are considered to be path breaking and original. Maxwell was inspired and influenced by Michael Faraday's electromagnetic theory. He arrived at the principles of electromagnetic lines of force on its basis. According to him, electromagnetic lines of force always exist in a closed circuit and are circular in form without an end.

Changes in the magnetic field create an electric field and changes in the electric field create a magnetic field. This way, magnetic field model was crystallised in Maxwell's mind. Earlier, Faraday had used the terms, lines of force and tube of force. He explained the changes taking place when a magnet is placed close to it. Maxwell went a step further to develop Faraday's ideas and put forward the unified theory of electromagnetism. Much later, his prediction of electromagnetic waves was verified by Heinrich Hertz.



Maxwell's magnetic force fields

To study further on electromagnetic forces and magnetic force fields, he left his job for a short time and proceeded to stay at his estate in Glinar. He wrote many books on heat, mathematics, colour vision and physical sciences. During this period, he came close to his neighbours and socialised with them. He would even play with children from the neighbourhood.

Maxwell also did monumental work in developing the kinetic theory of gases. He, together with his wife, conducted some experimental work on viscosity of gases.

Under pressure from the public, the Cambridge University decided to create a post of professor in the experimental physical sciences department to teach heat, electricity and magnetism. The Duke of Devonshire, Chancellor of the University, who was directly related to Henry Cavendish provided necessary funds for establishing Cavendish Laboratory. Maxwell was requested to head the

new laboratory. Maxwell was to direct research activities and was also empowered to buy new equipment for the laboratory.

Over and above the activities mentioned earlier, he would also write on diverse subjects. He would edit the writings of Henry Cavendish to ensure that the general public would be informed of his works. This way he would keep himself busy. He dedicated his life to science in this manner.

During the last two years of his life, he took care of his ailing wife. He was also aware that he was suffering from cancer, but did not let anyone know about it. Finally, on November 5, 1879 he died at the age of 48. World was unfortunately denied further benefits of researches and experiments of this esteemed scientist. Ten years later, Hertz invented the radio transmitter and receiver, thus validating the mathematical theory of Maxwell.

Maxwell's electromagnetic radiation theory played an important role in the understanding and making of Radar and microwaves. In reality Maxwell's theory contributed in clearly understanding the propagation of heat and light waves, radio waves, X-rays, gamma rays or any other type of electromagnetic radiation.

36

Alfred Nobel

Nobel Prizes were instituted in the memory of Alfred Bernhard Nobel who was born on October 21, 1833 at Stockholm, Sweden. His father was an engineer in the army. Alfred was the youngest of the three children. All children had primary education through private tutors at home. For further studies, Alfred was sent to Russia's famous city St. Petersburg, known today as Leningrad. The entire family shifted to St. Petersburg in 1842.

Nobel learnt Swedish and Russian apart from excelling in English, French and German languages. He went to Paris in 1850 to study chemistry. Thereafter, he went to study chemistry and engineering in America. After getting his PhD he returned to Petersburg. He joined his father at his factory. He was interested in exploring new areas in chemistry. Financial problems resulted in closure of the factory in 1859. He then returned to Sweden and planned to settle there.

Here, the father and son duo experimented on explosives at their laboratory. They experimented with nitroglycerine, a highly dangerous and explosive chemical. Once again they faced calamity in 1864 when their factory blew up. His brother Emil along with two workers lost their lives. The accident led the Swedish government to deny permission to set up a similar workshop. The public also rallied against such workshops. They found Alfred to be a whimsical scientist. Meanwhile, his father suffered a paralysis attack leaving Alfred to take care of the business. Not one to lose spirit, Alfred planned setting up units in Norway and Germany.

He was interested in manufacturing dynamite, a risk free and a useful explosive in comparison with the dangerous and volatile nitroglycerine. He finally succeeded in making it but not before undergoing pain and sufferings. The German factory also met a similar fate as his factory at Sweden. Engulfing fires and blast totally devastated it. Nobel went on working hard. He set up new factories. Despite the government ban on such plants in France and Belgium, he went on pursuing his goal. Britain and Sweden too proclaimed a ban on distribution of this chemical.

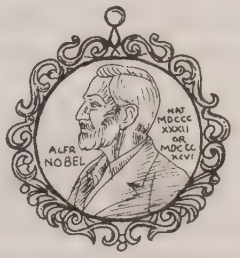
Nobel met ultimate success when in 1867, he manufactured risk free explosive and set to market it. Not many lives were lost due to accidents that occurred during its use. He also quietly achieved success in setting up factories in several countries that helped him amass wealth. He was now counted among the richest persons in the world. In 1887, he manufactured another explosive. It was a smokeless nitroglycerine powder. Many countries began using it as ammunition during wars. Nobel also took interest in developing artificial rubber, artificial silk and several other related products. He obtained over hundred patents during his lifetime. The world now began to take note of him.

Even as he went about accumulating his wealth, he was tensed. He was then not keeping good health. He was concerned and mentally disturbed over the misuse of explosives he had manufactured. He felt guilty about it. He feared his invention was not being used for productive purpose, rather it was being used as ammunition for weapons of mass destruction during wars. This made him feel responsible for all that was happening around the world. He only wished his invention of different explosives be used for peaceful purposes.

Nobel was a quiet scientist who loved solitude. This brave and adventurous scientist had infinite patience. He always wanted to try out something new and innovative.

This famous, great and wealthy scientist remained disturbed all the time. His conscience bit him carrying within the guilt of being responsible for the loss of innocent lives. Another cause of concern was the future misuse of all his inventions.

He had achieved immortal fame by the time of his death on December 10, 1896. He was 63 years old then. According to his will a corpus fund of $90,00,000 was set aside from the money he had earned. The interest amount accrued every year on this fund is distributed as Nobel Prize. He thus displayed his love for Science by instituting this prize.



Nobel Prize

The most prized honour in Science and indeed of this world, the Nobel Prize was instituted in the year 1901. They were presented in five different subject categories: (1) Physics (2) Chemistry (3) Medical Research (4) Literature and (5) World Peace.

In memory of Alfred Nobel (1833–1896), these prizes are presented to persons who excel and contribute for development in their respective fields, without discrimination on the basis of creed, race or nationality. No applications have to be filed to get the Nobel Prize. The Nobel Selection Committee on the basis of recommendations received selects from among Scientists, Litterateurs and Ambassadors of Peace for the Prizes and honours them. Apart from cash, the winners are given a Gold Medal and a Certificate. In 1990, every prize winner was presented $9,00,000. Nobel Prize is shared equally if two or more winners are declared from the same subject category.

The Nobel Institute of Sweden carries forward the ideals and spirit of Alfred Nobel. It conducts the presentation ceremony in Sweden befitting the manner

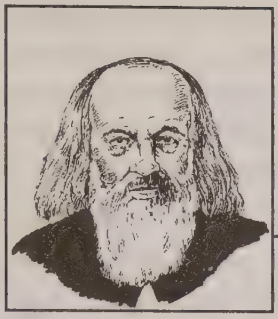
Nobel would have loved to honour people who contributed their mite returning something from what they had received from the world, like he had done. The world paid tributes to this great scientist by naming the element 102 in the periodic table as nobelium.

Since 1969, six instead of five category prizes are given. The Central Bank Of Sweden instituted the sixth prize for Economics and accorded it the Nobel Prize status.

The Sweden based Royal Academy of Science after having instituted Nobel Prizes for Physics and Chemistry instituted prize for Economics and the awardees are selected in a special way. Nobel Assembly of the Karolinska Institute selects the winner of the Nobel Prize for Medical Sciences. Literature Prize winner is selected by Stockholm based Literature Academy. Norwegian Parliament instituted a Nobel Committee that selects the Peace Prize winner. All the selected prize winners converge at Stockholm, Sweden, every year on 10th December, the death anniversary of Nobel to receive the prizes at a glittering public ceremony. The Peace Prize is presented at Oslo in Norway.

Rabindranath Tagore was the first Indian to be awarded the Nobel Prize for Literature in 1913. In 1930, Sir C V Raman was awarded the Nobel Prize for Physics. Dr Hargobind Khorana of Indian origin living in the USA was the next Nobel Prize winner for Medicine in 1968, while Dr S Chandrashekhar who had accepted American citizenship was awarded the Nobel Prize for Physics in 1983. Peace Prize was awarded to Mother Teresa also known as 'Saint of the Gutters' who worked for the destitutes of Kolkata. In 1998, London based Indian Amartya Sen was awarded the Nobel Prize for Economics.

Thus, Alfred Nobel atoned for inventing the deadly Dynamite by bequeathing his wealth in the form of awards to those winners who had most benefited mankind.



37

Dmitri Mendelayev

Dmitri Ivanovich Mendelayev was born on February 1, 1834 at Tobolsk in Siberia, in the eastern part of Russia. The Czar was then ruling over Russia. His father was a director of the local school. Dmitri was the fourteenth and the youngest of the siblings. Theirs was one of the leading families of Tobolsk. In 1787, Mendelayev's grandfather had set up a printing press. Siberia's first newspaper was brought out from there. His mother belonged to the Tatar's and was known for her beauty. Her family was also the first to start the glass-manufacturing factory.

Immediately after his birth, his father lost eyesight and so also his job. But his mother was very clever and did not lose her spirit. She restarted the closed glass factory belonging to her parents. This partly helped them financially. The political prisoners of Russia then were deported to Siberia to spend their long sentences. One of Dmitri's sisters married a revolutionary of the December 1825 revolution. He was educated and was sent out of Tobolsk. After sometime, the glass factory was destroyed in a fire and finally it had to be closed. Learning of Dmitri's thirst for education and his intelligence, his mother decided to continue his studies. Siberia then, had no reputed educational institutions. She then decided to shift the family to Moscow. Arriving in Moscow was an eye opener and here, he experienced difficulties that one faced in life. Not knowing Russian and speaking only Siberian, he was denied admission in Moscow University. He was 17 years when his determined mother moved the family

to St. Petersburg. First thing she did was to teach Russian language to her son. Then she enrolled Dmitri in a Teacher's training school where he learned physics, chemistry and mathematics. Though knowing only one language, he stood first at the graduation examination.

Dmitri's health was not as good as it was earlier. He had problem with his lungs. Loss of his mother then completely broke his heart. The doctors expressed their fears that Dmitri would not last beyond six months. He then shifted southwards to Crimea having dry climate. He got a job of a science teacher. But in a short while, war broke out. Dmitri had to shift to Odessa and then to St. Petersburg. He tutored some students at home during his spare time and earned some money doing so.

During this period there was no avenue for progress in Russia especially in the field of science as there were no facilities for research. One had to seek permission of the authorities to study abroad. Mendelayev sought permission for studying at France and Germany. He reached Paris and got a job as an assistant to experimental chemist Henri Regnault. A little later, he established his small laboratory to conduct research at Heidelberg. Here, he came in contact and worked with Robert Bunsen, the inventor of the famous Bunsen burner, and another famous scientist Gustav Kirchhoff. The three got together to construct spectroscope. Spectroscope is used in analysing light. It is also extremely useful in the study of analysis of chemicals. He attended the local Science Congress in Germany. He was fortunate to hear the famous appeal of Stanislao Cannizzaro in favour of Avogadro's work. Later, he utilised the atomic and molecular mass table of Cannizzaro. As a result, Periodic Table of all elements was constructed in the period 1868–69. This was the greatest contribution of Mendelayev–the Periodic Table of Elements. He got inspiration from here to construct the Periodic Table.

After completing study tour of France and Germany he returned to St. Petersburg. Finding a suitable match, he married only to divorce and settled down after remarriage. He also wrote a research paper on 'Carbonic Chemical Studies' in 60 days. Meanwhile, he wrote a thesis on water and alcohol mixture, which got him PhD. In 1865, when he was just 31, in recognition of his immense contribution and service to the progress of science, he was appointed the professor of chemistry at the Petersburg University. Attractive personality and a unique thirst for research led many students to seek inspiration from this young professor. His classes were always well attended.

Scientists were then aware of only 63 elements. It was Mendelayev who gave the Periodic Table, his invaluable contribution. Due to its unique and useful layout, all elements were arranged according to their chemical composition and nature. All 63 elements were arranged according to their atomic weight. The first was the lightest element hydrogen and uranium was the last, being the heaviest in element then. He constructed the periodic table with elements set in seven groups according to regularity in physical and chemical characteristic properties of elements.

Then, Mendelayev concentrated on the gaps in the Periodic Table. He began searching for new elements missing in the Periodic Table. He even predicted several of them along with their atomic weights. Among such elements were silicon, gallium, germanium and scandium that were discovered much later. The chemical characteristics predicted by Mendelayev matched exactly with those of the elements discovered later. This periodic table was regularly reviewed. Today, the elements are arranged according to their atomic number. Atomic number stands for the number of protons in the nucleus of an atom of the element. Atomic number of an element is

nearly equal to the atomic weight or mass of the element expressed in grams.

Mendelayev died in 1907 at the age of 73 suffering from pneumonia. When he was only 21, doctors had warned that he would not survive beyond six months. But fate had other designs for him. At the time of his death, the number of elements in the periodic table had grown from 63 to 86.

There are 92 natural elements. Apart from these elements, scientists have produced some new elements using nuclear reactions. The new element with atomic number has been named mendelevium after him.

38

Wilhelm Konrad Roentgen

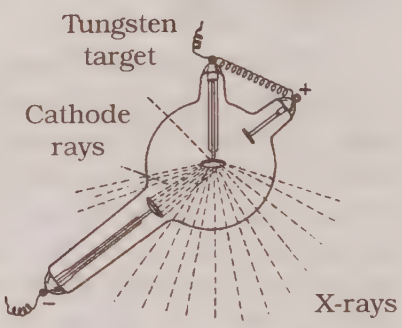
Wilhelm Konrad Roentgen, the man who discovered X-rays, was born on March 27, 1845 in Lennep, in the state of Prussia. His father was a German farmer and his mother was Dutch. He took primary education in Holland and for university education he went to Zurich University, Switzerland. Here, he had the opportunity to work under the famous scientist, Rudolf Clausius. Roentgen's favourite subjects were electricity, energy, light and elasticity. After receiving his doctorate in physics, he was appointed assistant professor at Wurzburg. He also taught at other universities in Germany and then returned to Wurzburg in 1885 as professor of physics.

Here, along with teaching, he got an opportunity to do research work. He studied the effects of electricity when passed through a gas at a low pressure in a Crookes tube. He carried forward the incomplete work of British scientists Michael Faraday and William Crookes. Faraday had studied the effects of electricity when passed through solid, liquid and gas. Crookes had fixed two electrodes to both ends of a gas discharge tube and then passed a high voltage electric current through it.

Now, Roentgen had better equipment to produce high vacuum in the tube. Besides, he had a good assistant too, who was an expert glass blower. He would heat the glass tubes and produce desired shapes out of them. He prepared a tube with two electrodes and created near vacuum in the tube. He connected both the electrodes to a high voltage

supply. He noticed that rays were produced near the negative electrode. Further study of the rays revealed that they could produce a shadow of the object kept in their path. They even forced a paddled plate to rotate that was kept in their way. When they hit glass they produced green coloured flourescence or glow. These rays, called cathode rays, were deflected by electric and magnetic fields.

Crookes' cathode rays consisted a stream of electrons. Roentgen tried to further Crookes' work from here. He covered the Crookes' tube with a thick cloth. In a Crookes' tube, the cathode rays travelled from the negative electrode to the positive electrode or anode. He inserted a blade of tungsten as a target between the anode and the cathode. When the cathode rays in the tube were deflected after hitting the target, they came through glass and produced images on the photographic plate placed nearby.



X-ray tube

Roentgen thought that these rays were different from the cathode rays obtained by Crookes, as cathode rays could not pass through glass. Roentgen named these unknown rays 'X-rays'. His friends and associates called them Roentgen rays, but later they came to be better known as X-rays.

He studied these rays more closely and discovered that even though the photographic plate was wrapped in black paper, the X-rays penetrated it producing the image of the palm on the photo-film. He concluded that these X-rays had the power to penetrate the flesh of a living being. However, they were unable to penetrate the bones as was proved by the image of the palm.

Image of the palm falling on the photofilm

When Roentgen announced his invention and demonstrated it in the assembly of Wurzburg Medical and Physical Society in December, 1895, experts present in the assembly immediately realized the importance of X-rays in medicine and other fields.

It surprised many that Roentgen's X-rays could penetrate the human flesh. To celebrate Roentgen's discovery, a dinner and dance party was organized. Many women stayed away from the party, lest the X-rays showed them without clothes in the party.

Gradually, with the spread of information about X-rays, people realized their utility. The misunderstanding regarding the rays also vanished. For his discovery, the Royal Society honoured him by awarding him the Rumsford award in 1896. Roentgen was awarded the Nobel Prize for Physics in 1901, which was introduced in the same year.

Today, X-rays have become extremely useful in detecting fracture in bones, surgery, etc. They are equally useful in the study of the internal structure of metals and other scientific researches. X-rays were discovered by the

end of 1895 and soon followed the discovery of radioactivity by Becquerel and many other important discoveries by some of the greatest scientists like the Curie couple, Rutherford, Planck, Einstein, Fermi, etc.

Following his important discovery in 1895, he was appointed professor of physics at Munich University in 1900. He worked there till he turned 75 in 1920. He died at the age of 78 in 1923.

39

Thomas Alva Edison

The scientist who invented the electric light bulb and many other important devices–Thomas Alva Edison, was born on February 11, 1847, at Milan, Ohio, in the United States of America. He came from a poor family. His parents admitted him to the local primary school. This inquisitive child always posed questions to his teachers. But his teachers instead of providing him with answers considered him stupid and rejected him. Finally, his self-respecting mother stopped his schooling and took upon herself the task of teaching him. Coupled with this, Edison loved to experiment. He would experiment with any object he could lay his hands on.

After getting permission from his father, at the age of 12, Edison started selling newspapers in trains. He would travel the 96 km distance from Huron port to Michigan city and sell newspapers. He liked his work, besides it brought him money. In 1869, he purchased a printing press. In a railway compartment he would print his journal

Grand Trunk Herald. Most of the content was written by him. He would also perform experiments during his spare time. During one such experiment, phosphorus fell on the floor and the compartment got engulfed in the fire. The rail-guard arrived and threw out all the contents of his laboratory. The enraged guard slapped Edison due to which he was left short of hearing in one ear.

It seemed as if the world had come to an end. But Edison didn't admit defeat and give up. It came as a blessing in disguise. Now he started selling newspapers at the station itself. He gradually got interested in electricity. His experience with engines and railroad repair shops turned his thoughts towards machines and inventions. One bright morning Edison was talking to the telegraph operator Mackenzie, whose little son Jimmie was playing at the station. In the middle of the conversation, Edison saw the little baby crawling along the stony track, in front of a small box-car. Edison realized the danger and rushed towards the child. He seized the child and jumped to safety, but the car struck him on the legs and ear. It was the second blow on his ear. As a reward for the brave deed, Mackenzie offered to teach Edison telegraphy and promised him a job on the line. A thrilled Edison grabbed the opportunity. He was lucky to have an offer for a paid job at the Port Huron telegraph office and at the age of 16, he got a better job as a night operator at a station in Canada, on the Grand Trunk Railway. Every hour he had to send 'signal six' which proved that the operator was awake. The signal came through from Edison's station exactly at the correct time. But attempts to get him over his own phone frequently failed. One night an official came to check and found Edison fast asleep. Beside him was a mechanism connecting the telegraph with the clock and when the clock struck the hour, the small machine sent the signal over the wire. He was fired. After work hours, he used his time to develop a 'Vote Recorder', which worked on electricity.

After a few days, he decided to move to New York for better opportunities. But life was not easy. Finding a job was difficult. While searching for a job, he landed up at a company office, which sold information to its clients about stock exchange rates through its machines. One of their machines, 'Gold Indicator' had broken down. Edison checked the machine and repaired it in minutes. The manager was pleased and immediately offered him a job besides rewarding him for his repair work. With this money he started a workshop in New Jersey. In association with another engineer, he developed a telegraphic equipment which fetched him a good price.

In 1876, he went to Menlow Park and improved upon the telephone invented by Alexander Graham Bell, by providing better sound quality by inventing carbon granule microphone. He also went on to invent a talking machine called the Phonograph. This machine could reproduce the pre-recorded sounds on a steel disc revolving on it. A German scientist improved the machine and made the gramophone in 1887. Edison gained quite a bit of reputation with his phonograph. But the height of his popularity came with the invention of the electric light bulb. In 1879, with the help of 30 assistants, he organized a public demonstration. He had covered a part of Menlow Park with electric light bulbs. The spectators were taken aback when he switched on the bulbs. The next morning the *New York Herald* published the news of this wonderful invention and Thomas Alva Edison became a famous man.

Within two years he again surprised the world with yet another spectacular invention. This time it was the kinetograph, a kind of movie camera. He even created a machine that could project visuals on a screen, which he called Kinetoscope. He connected the phonograph with it and projected audio-visual images on the screen.

This genius had 1,069 patents to his credit. He had noted down the intricacies of his inventions in about 3,500 notebooks. It is most surprising that this scientist was not awarded a Nobel Prize for his inventions, though he is considered as the greatest inventor of all times. In 1914, at the age of 67, Edison expressed his gratitude towards his nation by gifting the American Army with about 40 useful inventions.

On October 18, 1931, Edison died at the age of 84. He was buried at West Orange in New Jersey. This great inventor was honoured across America when electric light bulbs across the nation dimmed for a minute. He had worked his way up with great difficulty. He believed that his success was 1% inspiration and 99% perspiration. We are grateful to this self-made man who made this world a better place with hard work and perseverance, aided with extraordinary genius.

40

Alexander Graham Bell

Inventor of one of the most important features of the modern day telecommunication system – telephone – Alexander Graham Bell was born on March 3, 1847 in Edinburgh, Scotland. His father was a respected and well-known man. He had developed a special technique to train the deaf and dumb.

Alexander took his primary and secondary education at Edinburgh. As a child he gained a lot of insight and knowledge from his father. He had imbibed his father's traits to do something novel and path-breaking.

When he was a student, Alexander went on a day's visit to a hilltop with some schoolmates. There were haystacks on the hilltop and a flourmill nearby. Welcoming the children, the mill-owner inquired about their well-being. He then gifted each child a bunch of wheat stalks. Most of the boys threw it away on their way back, but Alexander took it home. He wondered how he could separate the wheat from the chaff easily and quickly. He cut the stalk vertically with a nail cutter and found it easy to take the grain out. He wrote about this simple technique to the mill-owner. The mill-owner designed an instrument similar to a nail cutter and put all the stalks into it. It produced excellent results. For his success, the mill-owner wrote a letter of thanks to Alexander.

After completing his schooling in Edinburgh, Alexander moved to London for higher studies. Later he went to Berlin University and completed his PhD. Meanwhile,

his health deteriorated and on his return home, it was presumably diagonised as tuberculosis. Earlier, his two brothers had died of TB. A worried father took him to Canada. The climate there suited him and he recovered fast.

Alexander went with his father to Boston, USA. Here, his father opened a training centre for the teachers of disabled children. In a short time Alexander received an appointment as professor in a university. He also got engaged to Chabel Hulbard, daughter of an advocate Gardiner Hulbard. They got married in 1877. A fever at the age of four had claimed Chabel's sense of hearing. Her parents had rushed her to Germany, so her speech was spared. It was a time when teaching the deaf and dumb was not welcome and thought to be interfering with God's decree. Objections were raised against such an activity. But Bell and Gardiner succeeded in getting an ordinance passed in their favour from the assembly of Massachusetts.

Now, Bell was interested in a training institute for teachers of the dumb and the deaf. But his thoughts took him further. He was immersed in inventing an instrument, which could be used to talk over long distance. For this, he studied deeply the structure of the human ear. He concluded that man could hear thanks to a thin screen or drum in the ear, which vibrates, enabling one to hear the sounds. The drum vibrates due to sound waves. He created an artificial screen and with the help of electricity effected vibrations on it. With the help of electricity he was able to transfer high and low intensity human sounds from one place to another. This way he developed the concept of the telephone. For this he had rented two rooms on separate floors of a boarding house in Boston, which served as his laboratory. He had also appointed an assistant named Watson. The day arrived when he was able to communicate between the two floors through telephone. Watson, sitting on the ground floor could clearly hear his master's voice

from the upper floor. An excited and happy Watson rushed upstairs to inform Bell of his achievement. Bell was delighted and thanked God for the success of hard years of toil. Thus, Bell's telephone came into existence, though he had to face some problems later.

At that time an exhibition was held in Boston. Bell exhibited his invention to demonstrate to the public in Boston. But people were not interested. And then the king of Brazil visited the exhibition and got interested in Bell's instrument. He talked to Bell through the instrument and congratulated him for the clear sound quality. Now, people too were attracted to his invention. For his revolutionary invention, Bell became a famous man overnight.

Troubles followed. Inspired by this invention some opportunists copied Bell's design and started marketing it as the original instrument. They claimed that Bell had copied their idea. Bell was dragged into court over the matter. Bell won the case. This incident established him as the inventor of this revolutionary instrument and also earned him enough fund for the mass production of telephones.

He started a firm called Bell Telephone Company in partnership with two other men. By then, Bell had received fortune and fame. He bought a large villa and shifted there. Bell was not one to sit back and enjoy his wealth. He went on to invent the Bell photophone and gramophone, but he is primarily known for the invention of the telephone. He kept exploring the possibilities in all the fields to create something novel, something useful. He even prepared a huge kite that could help a man fly, but crashed. He even thought of a technique to help breed twins in cattle, but was unsuccessful. Some of his efforts were successful, while he failed in others. In other fields, he never achieved the success he got from telephone.

Now, his homeland beckoned Bell. He returned to his native Edinburgh a famous man. England and Scotland felicitated him. Besides, other countries honoured him with titles and medals. The Universities of Canada, America, Germany and Scotland conferred on him honorary degrees. For his discovery, the French government declared him the winner of the Bolta Medal and announced a cash prize of 50,000 francs in 1880. He utilized the money to establish a laboratory at Bolta.

Though the world knows him as the inventor of telephone, he personally believed his work for training the deaf and dumb to be his highest achievement. He had published many research papers which included 20 papers relating to telecommunications like telephone, photophone, spectophone, etc., 4 papers on medicine and surgery; and more than 18 papers on various other topics like lifespan, cattle upkeep and air-flight. Thus he had carried out research in eight varied fields.

This great scientist died at Binbhrig on August 2, 1922, at the age of 75. All the telephones working on Bell technology were kept off the hook for two minutes in his honour. His gravestone at Binbhrig reveals the words of his choice: "Born in Edinburgh and died as an American citizen."

The Bell Company at New Jersey continues research in today's telecommunication industry. The company was renamed AT & T and has fulfilled Bell's dream of making this world a global village.

41

Henri Becquerel

Henri Becquerel was born in one of the world's most beautiful city, Paris, on December 15, 1852. His father, Alexandre Edmond Becquerel (1820–91), his grandfather, Antoine César Becquerel (1788–1878) and his son Jean Becquerel (1878–1953) too, were all scientists. Thus, Henri was born in a well educated and cultured family of scientists. After his early schooling at the Lycée Louis-le-Grand, Henri received his formal scientific education at the École Polytechnique (1872–74) and had engineering training at the École des Ponts et Chaussées (Bridges and Highways School 1874–77).

In addition to his teaching and research posts, Becquerel worked as an engineer in the Department of Bridges and Highways for many years, being appointed chief engineer in 1894. He took up his first academic position in 1876 as assistant teacher at the École Polytechnique, where in 1895 he succeeded to the chair of physics. Concurrently, he was assistant naturalist to his father at the museum, where he also assumed the physics professorship upon his father's death. Becquerel studied the effects of radioactivity and radioactive decay. In this study he found that when ultraviolet light falls on the material, it tries to absorb the radiation energy. Due to this, electromagnetic radiations are emitted. The material radiates if it is in an excited state with the help of electromagnetic radiations or if it is made up of highly charged and energized particles. Till the energy to radiate is present in an object, the event or phenomenon

is visible. This is known as phosphorescence. When the object stops radiating light it gets into a state called radioactive decay when there is no radiation visible.

Becquerel then concerned himself with infrared radiation, examining, among other things, the spectra of different phosphorescent crystals under infrared stimulation. He extended the work of his father by studying the relation between absorption of light and phosphorescence in some uranium compounds. In 1891, his father Alexandre died and in his place Henri Becquerel was appointed. In this way the third generation of Becquerel took over the prestigious position and justified his appointment. He extended the research in the field. He used the sun as the sole energy source. He never had any sophisticated or costly instruments for his research. Some salt crystals of uranium, or a some photographic plates and the never ending source of light–the sun was all he had. Becquerel would store photographic plates from light in his drawer wrapped in a thick black paper. One day, when it was unusually cloudy with no sight of the sun, he wrapped a small specimen of the element in the black paper around the photographic plate which was unexposed, and left for home. Next day he returned to check the plates. Becquerel wondered whether some unknown rays like X-rays discovered by Roentgen earlier, had left behind their traces on the photographic plates. He studied the plates and after developing them found the traces. He came to a conclusion that uranium and potassium sulphate have some kind of radioactive substance that leave behind traces on a photographic plate.

Becquerel rechecked his experimental results and finally arrived at the conclusion that uranium salts constantly radiate some rays which affect photographic plates. This was indeed a new and wonderful discovery. Exactly after one year after the discovery of the famous X-rays, Becquerel announced this discovery. Becquerel's

co-researchers termed them as Becquerel rays. In 1898, Madam Curie renamed these radiations as radioactive rays and the corresponding activity as radioactivity. Radioactive rays consist of (positively charged) alpha particles, (negatively) beta particles and uncharged gamma rays.

Other scientists were drawn to studies of radiation phenomenon due to Becquerel's researches. His contemporaries Pierre and Marie Curie achieved remarkable success in the field. They discovered new radioactive elements thorium, polonium and radium, which was several times more radioactive than uranium.

In 1903, Henri Becquerel shared the Nobel Prize for Physics with Pierre and Marie Curie. The last decade of the nineteenth century saw many important discoveries. Further research was carried out after the discovery of Becquerel rays. In 1897, Sir Joseph John Thomson analysed the radioactive rays and discovered negatively charged beta particles. Thereafter, Ernest Rutherford and other scientists studied alpha particles and proved that they are positively charged. Paul Villard discovered gamma rays which are electromagnetic radiations of very short wavelength and have maximum penetrating power among alpha, beta and gamma rays.

This great scientist died at the age of 56 on August 25, 1908, at Le Croisic, France. His discovery of radioactivity has been of vital importance and utility to us, even today. Radioactive isotopes have many applications. Geo-physicists in particular, have found multipurpose utility of it. With the help of isotopes, they can determine the age of earth, rocks, mountains and oceans. Apart from this, important and useful information about comets, moon rocks and rocks from Mars and other planets can be obtained. They can determine the precise age of the rocks. The Physical Research Laboratory based at Ahmadabad, has developed the facility to determine the exact age of

any sample including the age of archaeological specimen. It has been developed as a national facilitation centre. One can send any sample to this centre to know its exact age. In times of peace, such radiations are used to develop new methods for the benefit of industries, medical sciences and agriculture.

42

Albert Michelson

Albert Abraham Michelson was born on December 19, 1852, to a German Jewish couple in Strelno (now Strzelno), Prussia (presently in Poland). In 1848, the Liberals in Germany advocated equality in taxes and freedom of speech. But by the time of Albert's birth it was almost clear to them that the changing political scenario would make it difficult for them to live in Germany. And they started leaving the country to safer places. Some of them came to America and among them were the Michelsons who reached New York in 1854. Albert was just two years old then.

After a while, they sailed to the western shore and reached California. By 1849, California had acquired the reputation of the promised land of gold. Albert's father, Samuel Michelson owned a small dry-fruit shop in Cleaver's county. Albert received primary education in the local school. For high school, he was sent to San Francisco. He was a bright student. Besides mathematics and science, he was well-versed in handling mechanical devices. For

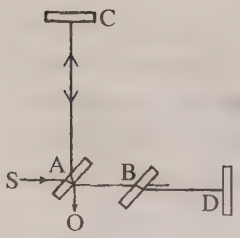
his adroitness, he was given charge of the scientific equipment in the school laboratory. He was paid $3 per month for his work.

In 1868, when Albert turned 16, his family moved to Virginia in Nevada State. Here silver mining was a major activity at that time. A year after they came here, his brother Charles was born, followed by the birth of his sister Mariam the next year. Charles went on to earn name as the publicity director of the Democratic Party during American President Franklin D Roosevelt's regime.

Albert graduated from the Naval Academy in 1873. As per Academy rules, he served in the American Navy as 'assignee' for two years. On completion of duty, he was called back at the academy and appointed as teacher of physics and chemistry. During this time he developed an interest in the study of light especially the various techniques to measure the speed of light, which sustained throughout his life.

Using Foucault's method of revolving mirrors, Michelson developed his unique technique to measure the speed of light. With some lens available in his laboratory besides spending $10, he developed this technique. He could accurately measure the speed of light in the vicinity of 500 feet. In 1878, his first research paper was published in the American Journal of Science. It was titled 'Measuring the Velocity of Light'. Using this new technique, the speed of light was found to be 1,86,508 miles/second.

Thereafter, he concentrated on the colours seen in a soap bubble. He studied the refraction in the surface area of the bubble. He explained that if the layer of soap film has half the wavelength of light, the two waves do not interfere and hence, do not get destroyed. Sir Isaac Newton too had studied the colours in bubble. But he did not believe in the arguments regarding the wavelength of light, so could not put forth any explanation for it.



Simple diagram of Michelson's Interferometer

It was known then that if the thickness of the soap film is known the speed of light can be determined. But it was a difficult task. In 1887, Michelson designed an instrument that made him world famous. This device was called 'Michelson Interferometer'. Even today in colleges students of physics use this device to measure the wavelength of light. Here, a partially silvered glass plate divides a light ray into two parts and two such waves coming from different directions would get refracted and interfere to form straight fringes under certain conditions, making it easier to measure the wavelength.

A mystery that puzzled scientists then was whether light waves need a medium to travel like sound waves. How does light travel from the Sun to the Earth? Scientists thought of a substance called ether, but were not sure about it. Michelson and his assistant Morley performed the experiment to test the ether hypothesis. At that time Michelson was professor of physics at the School of Applied Sciences in Cleveland. He later moved to Clarke University and in 1892 joined Chicago University as professor of physics and head of the department. Here, he could concentrate more on research, as his lectures were limited. He was a great disciplinarian. He always assessed his findings. Probably this could be the reason he could not mix freely with his students like Einstein or Fleming. But he had a tender heart and music was his only hobby. He was a good violinist and taught violin to two of his six children from two marriages.

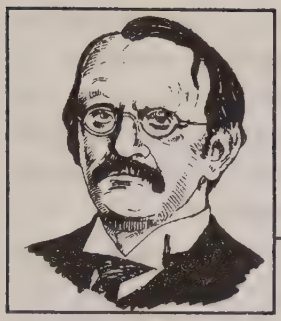
The world of science always held Michelson in high esteem. Several institutions honoured him. He was honoured with the Nobel Prize for Physics in 1907, the first American to receive the award. Eleven universities all

over the world conferred on him honorary doctorates. London's Royal Society awarded him the Rumford Medal. He was also honoured with the Grand Prize in Paris and Exposition Prize in Rome. In 1892, the International Bureau for Weights and Measurements in Paris honoured him by awarding him an honorary membership.

In 1926, Michelson performed a new experiment to measure the speed of light. In this experiment too he used Foucault's principle of revolving mirrors. For this a special centre was set up on Mount Wilson in California. Exactly 22 miles, i.e. about 35 kms away on Mt San Antonio, another mirror was placed. Then light waves were sent from Mt Wilson.

At the same time the mirrors started revolving. The light wave travelled to Mt San Antonio, got reflected from the revolving mirrors and returned to Mt Wilson. During this period the mirror had completed a sixth of its revolution. Thus, he once again proved his technique to measure the speed of light.

Michelson worked till his last breath. This great scientist died due to brain haemorrhage at the age of 79 on May 9, 1931.



43

Sir J J Thomson

Sir Joseph John Thomson was born on December 18, 1856 at Cheetham Hill near the industrial city of Manchester in England. His father sold rare books as a bookseller. This was their traditional family business. There was no scientific background at home, except his uncle who had a casual interest in meteorology and horticulture.

Since childhood days Joseph had the habit of reading. But, life surrounded by books fueled his interest in reading. His family members encouraged him to take up engineering seeing his interest and sincere efforts at study. At the age of 14 he was admitted to Owens College, Manchester. Today this institution is famous as Victoria University of Manchester. Two years after he joined the college his father passed away. His relatives took up the responsibility of his education. Fortunately, the John Dalton Scholarship also came his way, which further helped his education.

At the age of 20, Thomson successfully completed his graduation in engineering and entered Trinity College, Cambridge University on scholarship. The college was a favourite one among students interested in mathematics and science. A competitive examination called 'Mathematics Tripos' was conducted here. Thomson appeared for the examination and scored high grades. Like James Clerk Maxwell, he too stood second. Again, following Maxwell's footsteps, he moved from mathematics to theoretical physics. Though he was not very good at performing experiments, he never underestimated the importance of it.

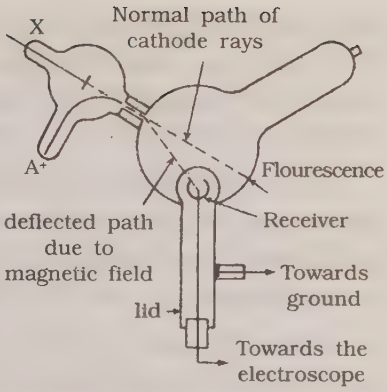
In 1881, at the age of 24, he wrote a research paper, which gives us some idea about Einstein's theories. In the paper he explained that energy and matter maintain a balance in nature. After obtaining his degree, he also received the fellowship at Trinity. He started research work at the renowned Cavendish Laboratory.

In 1884, the head of the Cavendish Laboratory, Lord Rayleigh decided to relinquish his post and named the 28-year-old J J Thomson as his successor. This created an uproar. Though there was no doubt about his calibre, his young age caused the abashment. But Thomson lived up to the expectations and successfully managed the affairs of the institution for the next 34 years. He led the institution to become one of the best research institutions in the world.

It was a happy coincidence that at the institution where he conducted research, he met his better half. Thomson believed that women could not be good researchers. So, when Rose Paget, a student, approached him with some questions, he thought that she could not follow anything. They married in 1890 and two years later, Rose gave birth to their first child, who later became the famous scientist Georg Paget Thomson (G P Thomson). In the presence of 80-year-old J J Thomson, his son was conferred the Nobel Prize for Physics in 1937. G P Thomson was awarded the prize for his research on the demonstration of wave nature of electrons.

In 1887, Thomson discovered a very minute particle –electron, and came to be known as the 'Father of Electron'. With this discovery he proved electrical characteristic property of matter. It was a time when extensive study of cathode rays was on. He stated that cathode rays consisted of electrically charged particles. Some scientists believed that cathode rays and electrically charged particles were totally different entities. But it was equally true that when the cathode rays collided with glass, they produced glow.

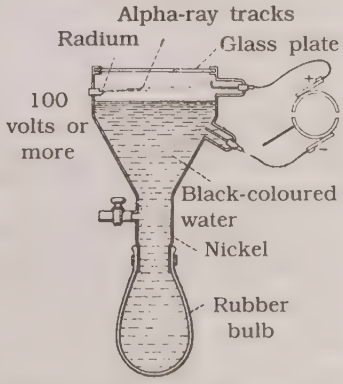
An electrically charged particle or electron cannot be seen with naked eyes. Thomson also proved the fact that cathode rays deflected in presence of magnetic field, thus proving that cathode rays contained negatively charged particles. His critics argued that mere deflection of cathode rays in presence of magnetic field did not prove that the electrons were negatively charged. Thomson created better vacuum in the cathode ray tube to prove that the cathode rays deflected only due to magnetic and electric fields. He insisted that cathode rays were not just rays but a stream of electrons.



Cathode rays consist of electrons

He calculated the velocity of rays by balancing the opposing deflections caused by magnetic and electric fields. Knowing this velocity and using a deflection from one of the fields, he was able to determine the ratio of electric charge (e) to mass (m) of the cathode rays. He also measured the weight of an electron and proved that it was 2000 times lighter in weight than hydrogen atom. He also determined that the velocity of an electron to be 1,60,000 miles per second.

J J Thomson's basic research, led to the invention and usage of Television in our day-to-day life. TV is a cathode ray tube where electrons get deflected due to the effect of electric and magnetic fields. Thomson did the same, but none believed him way back in 1897. He even thought of

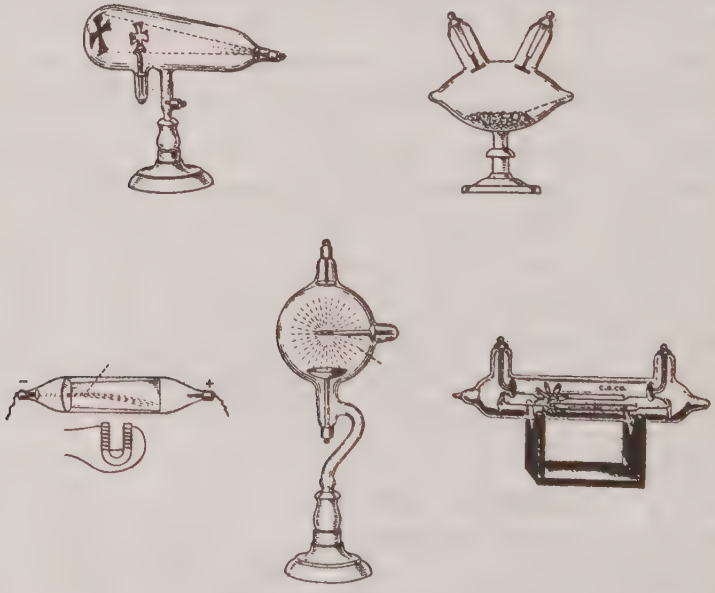


Wilson cloud chamber

photographing electron. He assigned the task to his student C T R Wilson, who in 1911, devised a method to observe tracks of charged particles by constructing what is now known as Wilson cloud chamber.

For his wonderful invention, C T R Wilson was awarded the Nobel Prize for Physics in 1927. All such research established the existence of an electron and gave birth to a new science called electronics.

With the end of World War I, Thomson gave up the directorship of Cavendish Laboratory to be the chairman of Trinity College. One of his colleague and a friend, Lord Ernest Rutherford, was handed over the charge of Cavendish Laboratory.



Cathode ray tubes

Thomson was honoured with the Nobel Prize for Physics in 1906 for his research in electrical conductivity of gases. The British Government knighted him. Truly, he was a talented teacher, a researcher of the highest order, one who provided excellent leadership to young scientists. Eight of his students were recipients of the Nobel Prize.

Sir J J Thomson was known as the 'man who split atom'. He also wrote several high quality books for students. Sir J J Thomson, the great scientist, died at the ripe old age of 84 in 1940.

44

Heinrich Hertz

Heinrich Rudolph Hertz was born on February 22, 1857, in a well-to-do family in Hamburg, Germany. His parents began his education with the intention of shaping his career in architecture and engineering. But soon they realized his interest in pure science and research. He was a curious child with a habit of observing and learning about new ideas and things. Heinrich joined Berlin University, where a person of rare intelligence, versatility and multifaceted personality–Professor Hermann Von Helmholtz, taught various subjects like physiology, anatomy, physics and mathematics.

On the basis of his researches in physics, he conducted research in measurement of the speed of the throbbing of arteries. He produced electromagnetic waves in the laboratory and analysed their wavelength and speed. He also conducted analysis of oscillation and speed of sound waves, principles of rhythm in music, gave a new statement on the conservation of energy; principles of the colour spectrum, etc. Besides, he also invented the ophthalmoscope, to check eye diseases. This equipment is used even

today for observation and correct diagnosis of the eye diseases.

Hertz learnt a lot under the able guidance of Helmholtz. At the same time, Helmholtz also realized that he had a very talented pupil in Hertz. Both reciprocated each other with satisfaction. Hertz graduated in 1880 and was soon appointed as his deputy by Helmholtz in his research work in physics.

In 1883, he was appointed professor of physics at Kiel in Northern Germany. He joined it and worked on Maxwell's electromagnetic theory. The theory of electromagnetism was first published in the form of an essay in 1865. Many of the present day advancements in science are based on this theory. Hertz's initiation into research brought him fame and provided him a new direction in research.

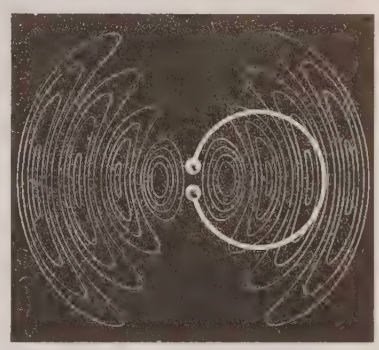
He now concentrated on the experimental study of implications thought out of Maxwell's mathematical equations. He wondered if electromagnetic waves could also travel like light waves. He also began to visualize on the experiments that could be conducted on the subject. Meanwhile, he joined Karlsruhe Polytechnic as professor of physics. Now he thought of conducting research on the production and propagation of electromagnetic waves. He wondered how much time it would take to propagate such waves from one place to another and how to accurately measure such a small interval of time?

He constructed the world's first radio transmitter and radio receiver for the purpose, generating radio waves. Prior to this no one had heard about it. Hertz's equipment later laid the foundation for invention of the modern radio, radar and television.

He conducted his experiments in a small $10\,m \times 10\,m$ room. A wave travelling from one end to the other and back covered a distance of 20 metres. It was very difficult to measure the time taken by the wave to cover this

distance as it was expected to be less than one microsecond. A brilliant idea struck him–a Leyden jar could be used for the purpose. A Leyden jar (a type of capacitor) could be used as an instrument to measure time because the electric discharge that took place between two points was a very fast process. Another thought that struck him was that there could be some conductor, which could produce electric discharge.

Hertz demonstrated the production and propagation of radio waves (electromagnetic waves of long wavelength). Next, he wanted to prove that however brief, a wave took specific time to reach from one point to another point. For this, he once again returned to sound waves and dwelt on Helmholtz's work. Waves originating from the same source but reaching destination by separate paths could either be weak or very powerful. In terms of frequency modulation one can call them constructive or destructive. As the receiver moves from one point to the other, the vibrations will cease at a certain nodal point which in scientific terminology is called destructive interference. The distance between two such points is equal to half the wavelength. Hertz succeeded in measuring the wavelength of an electromagnetic radiation using the phenomenon of interference.



Electromagnetic waves can be produced through the spark-gap

Thereafter, Hertz studied many properties of the electromagnetic waves: like the radiations of light, these electromagnetic waves can be focused, distorted, reflected, refracted, polarized, etc. Similarly, he also measured the speed of the electromagnetic waves, which equalled the speed of light, i.e. 3×10^8 metre/second. Thus, through a

series of experiments Hertz proved that the electromagnetic waves were quite similar to light waves. "My experiments have proved the solidarity of Maxwell's doctrines." He would say this in all modesty.

In 1889, at a meeting held at Heidelberg, the Association for the Advancement of Natural Sciences described and discussed Hertz's experiments and findings. Researchers and scientists present at the meeting lauded his efforts. At the age of 32, Hertz was appointed professor of physics at the University of Bonn.

Hertz met an untimely death, due to blood poisoning, at the age of 37 in 1894. The SI unit of frequency, the Hertz (Hz), is named after him.

45

Max Planck

Max Karl Ernst Ludwig Planck was born on April 23, 1858, in the Baltic seaport city of Kiel, Germany. Kiel was then ruled by Denmark. Max was the sixth child of a distinguished professor of law at Kiel. Soon, Kiel was freed from Denmark with the German army's help. His father then joined as professor of Law at the Munich University. Max came from a distinguished and educated family. His relatives had earned name and fame in the fields of law, public services as administrators, and as scientists and preachers among others.

When Max was 9 years old, his father shifted the family from Kiel to Munich as he was appointed professor at the Munich University. Max began his school education at the Maximiliam Gymnasium in Munich. Here, he came in contact with a philosopher and a dedicated professor of physics who inspired and drew him towards physics and mathematics. He was also fond of music. His family would support and encourage him in his musical pursuits. He became a very good pianist and playing piano became a passion of his life time. He would relax playing it after a hard day's work. He also loved the outdoors, taking long walks each day, hiking and climbing in the mountains during vacations, even when he grew old.

He studied at Munich University from 1874 to 1876 and from 1879 to 1880 and at Berlin University from 1877 to 1878. He had the opportunity to study under the able guidance of professors Hermann Helmholtz and Gustav Kirchhoff. He presented his thesis on the expansion of hydrogen when it was passed through palladium. It earned him doctorate in 1880. This was his first and last experimental research and it lay at the core of the researches that led him to discover the quantum of action, now known as Planck's constant h, in 1900. The value of h found by Planck was 6.55×10^{-27} erg-second, close to the modern value. After his doctorate, he did research in theoretical physics.

It did not take long for Planck's intelligence and brilliance to get noticed. He was appointed assistant professor at Munich University and soon, he moved to Kiel as professor of Theoretical physics. At the age of 31, he was appointed professor of physics at the Berlin University. He was contemporary of the famous physicists Sir J J Thomson and Heinrich Hertz.

His intellectual capacities were however, brought to a focus as a result of his independent study, especially of Rudolf Clausius' writings on thermodynamics. It is a

systematic study of the relationship between heat, work, temperature and energy. In fact, thermodynamics and the science of light are closely related. Normally, a thermometer is used to measure temperature up to a certain degree and for temperatures above that, it is determined from the spectrum of the substance. An optical pyrometer is used to measure the temperature of a furnace. Heat and light are in fact types of energy. So, Planck extended his study beyond thermodynamics to study light.

Planck faced some theoretical problems in his research on radiation. He researched on the amount of light needed to produce heat. He discovered that very little amount of heat brightens a substance. Every object has some amount of heat due to which it glows. But in reality it does not happen so! All his calculations were correct. Thus, he felt there were certain loopholes in the established laws regarding light. This revolutionary scientist took up the challenge to question and reject the age-old prevailing principles.

Planck formulated new principles. He put forward the hypothesis that light is a stream of energy and energy emitted in specific amounts or quanta. According to him, different levels contain different amounts of energy. According to Planck, the energy associated with a quantum of radiation is proportional to the frequency of radiation, and the constant of proportionality (now called Planck's constant h) is a universal one. Planck's new theory came to be known as 'quantum theory'. Max Planck presented his new theory to the German Science Academy in December 1900. Many scientists present at the meeting did not accept the new theory. They had another reason. They found the age-old theory of light–Corpscular Theory or particle theory being revoked here. They felt that the wave theory readily explained reflection, refraction, interference and polarisation, etc. of light. So, how could the wave theory be dismissed? They were not mentally prepared to accept this.

At the same time, Albert Einstein was working on his Theory of Relativity in Switzerland. He made it clear that Planck's Quantum Theory could easily solve some problems of Photoelectricity, which the wave theory failed to solve.

In 1905, Albert Einstein used Planck's idea of light quantum hypothesis to explain photoelectric effect which could not be explained using the wave theory of light.

In 1913, Einstein arrived at Berlin and the two great scientists of the time came together and became great friends. They shared their common interest in music –playing piano. Einstein contributed significantly in establishing the quantum theory. Steadily, the scientists of the world accepted Planck's quantum theory. In 1918, he was awarded the Nobel Prize for Physics for his quantum theory of light.

Planck was a man of strong spirit and will power. If he had been less tolerant, less philosophical and had even lesser religious belief, he probably could not have succeeded in overcoming the tragedies that marred his life after his 50's. In 1909, his first wife, Marie Merck, daughter of a Munich banker, died after 22 years of happy marriage, leaving Planck with two sons and twin daughters. He married again and had three children from the second marriage. He lost his elder son Karl in action in 1916 during World War I. The following year, Margarete, one of his daughters, died in childbirth, and in 1919 the same fate befell Emma, his second daughter. The terror unleashed by the Nazis compelled his two dear friends Albert Einstein and Erwin Schrödinger to leave Germany for good. He was to face further tragedy with the advent of World War II. The house in Berlin where he lived was totally destroyed by bombs in 1944.

The Nazis could not compel Planck to sign the Declaration in favour of Nazism. He was constantly harassed to sign it, but he did not do so. They again approached him in 1944 with even more pressure. Planck

was 86 years old then, while his only remaining son Erwin, was in prison accused of being a traitor. They agreed to release Erwin provided Planck signed the Declaration. But Planck categorically refused to sign and as a result, Erwin was shot dead. Later, he lost his property and his personal library in war blitz. This old scientist withstood all the tragedies without forsaking principles which were so dear to him.

Germany suffered a massive defeat at the hands of the allied forces. A new and strong German nation emerged as the Nazi regime came to an end. Nazism lost its grip over the psyche of the people. New German administrators organized a grand function to celebrate the 90th birthday of this great scientist. Unfortunately, he passed away on October 4, 1947, a few months before the big day. The Kaiser Wilhelm Academy of Science was renamed Max Planck Academy of Science in honour of this great man. Moreover, the German medal for foremost research called Max Planck Medal is awarded every year in his honour.

46

Madam Marie Curie

Madam Curie, the discoverer of radium, was born Marie Sklodowska on November 7, 1867, in Warsaw, Poland. Her father belonged to a farmer family, but studied at the Warsaw High School and took up teaching mathematics and physics there. Her mother was a good pianist. When Marie was 10 years old, she lost her mother due to tuberculosis. At that time, the Russian Czar ruled Poland. Marie's father was forced to leave school for his revolutionary speeches and took up the cause for freedom struggle. He started a boarding house for students, but it did not do well. He could hardly manage a square meal for his family.

Marie's elder siblings Bronia and Joseph, won gold medals at high school. Joseph was admitted at university to study medicine. Poland did not have any provision for higher education for girls, so her father asked Bronia to take tuitions in Warsaw, save some money and then go to Paris for further medical education.

Since childhood, Marie had a very good memory and at 17, won the gold medal on completion of her education from the school at the Russian lycée. As her father, a teacher of mathematics and physics, lost his savings through bad investment, she had to take work as a teacher and at the same time, took part clandestinely in the nationalist 'free university' reading in Polish to women workers. To improve her failing health, her father sent her to spend some time in the rural area. On her return after a year, her father found her a healthy and beautiful girl.

Seeing the family's weak financial condition, both sisters decided to help their father. One would work and the other would continue study. Bronia left for Paris to study medicine and Marie started earning. After struggling to get some decent work, she was engaged as a governess. Gradually, she became part of that family. When the eldest son of the family studying at Warsaw University returned, he immediately took a liking for Marie. Both were attracted towards each other. But his mother did not approve of this relationship between her son and a maid. Heartbroken, Marie left the job. She even thought of committing suicide, but nature had something else in store for her. She soon got another job. Meanwhile, Bronia completed her studies and married a classmate. Sometime later, her sister asked Marie to join them in Paris.

In Paris, the 23-year-old Marie resumed study in science at Sorbonne University. She worked very hard for four years. She rented a small room on the upper floor of a house in a poor locality and concentrated fully on her education. She lived a life with limited means. Winters were particularly difficult, for she had a few warm clothes. Meat, wine or eggs were luxuries she could ill-afford. She used to earn by doing odd jobs. She appeared for her post-graduation examination in physics in 1894 and stood first. Next year, she again appeared for mathematics and stood second. She had finally realized her dream.

Keeping her father's word Marie had excelled at studies and returned home. An aging father and poor family conditions made her realize that she had to cut short her studies in Paris and stay at home. But destiny willed otherwise. In Warsaw, she met a rich lady from an aristocratic family. After hearing Marie's story, she arranged for her scholarship. Encouraged by future prospects, Marie immersed herself in further study. With her father's blessings she set off to Paris.

Improvement in her family's financial situation, coupled with her good results, spurred her to concentrate on her studies. Once, a Polish scientist Prof Kowalski came on a visit to Paris. He asked Marie to come to his place for discussion. Here, she met another talented young man– Pierre Curie. Marie's talent impressed him. He expressed his wish to see her again. After courting for a year, they got married. Marie Sklodowska became Madam Marie Curie. Pierre was a scholar and a wonderful human being. He had graduated with physics at the age of 16 and acquired a post-graduate degree at 18. Besides, he had also researched on piezo electric effect. His father was a well-known doctor. After marriage, Marie and Pierre Curie started working together.

Meanwhile, German scientist Wilhelm Roentgen had discovered X-rays, a short wavelength radiation having immense capacity to penetrate through solid objects and human body. This discovery in December 1895 sent ripples across the world of science. At the same time, Henri Becquerel was carrying out research on fluorescence. After several experiments, he had come to the conclusion that there was some other element besides uranium in the raw metal pitchblende. Impressed by Marie Curie's talent, he came to meet Marie to seek answers to some problems he had been facing. Marie and Pierre Curie took up the challenge willingly.

In 1896, Becquerel discovered that some unknown rays constantly emanated from pitchblende. These rays were initially called Becquerel rays. Later, Madam Curie worked on it extensively and named this radiation type of activity as radioactivity, and the rays were called radioactive rays.

In 1897, Marie gave birth to a healthy baby girl. She was named Irene. Some time later, Pierre's mother passed away. His doctor father moved in to live with the Curie family. Marie had left her daughter, Irene, under the care

Pierre and Marie Curie working in the laboratory

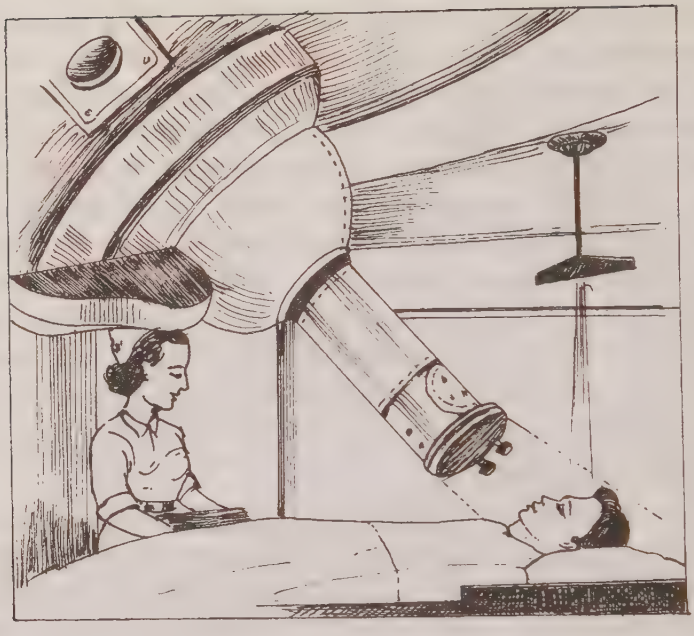
of a maidservant. Having a father-in-law around with a baby girl, under the care of the maidservant, they could work hard in the laboratory. Later Irene followed the footsteps of her illustrious parents and earned fame. Along with her scientist husband Juliot, she won the Nobel Prize for Chemistry in 1935.

The Curie couple was sure that in pitchblende besides uranium, there was some strong radioactive element present. To separate this element from uranium was a challenge. Pitchblende was a very expensive ore and was not easily available. They came to know that Austria possessed pitchblende in abundance. They requested the Austrian government to release some pitchblende after separating uranium from it, for their research. The government agreed to provide the ore free, but the transportation was to be borne by the Curies. Finally, tons of pitchblende arrived in ships and were unloaded in a

wooden shed in the Curies' laboratory. They placed the pitchblende in a huge iron pan and allowed it to boil. Thus, an unused shed became their laboratory. Two years of perseverance resulted in the separation of a small quantity of a compound of bismuth which was 300 times more powerful in radioactivity than uranium. In July 1898, they announced the discovery of a new element, which was named polonium after Poland, Marie's motherland. All this time, they were aware that their search for the most powerful radioactive element was not over yet. They continued their experiments and at the end of crystallisation process they noticed some crystals of the new element radium.

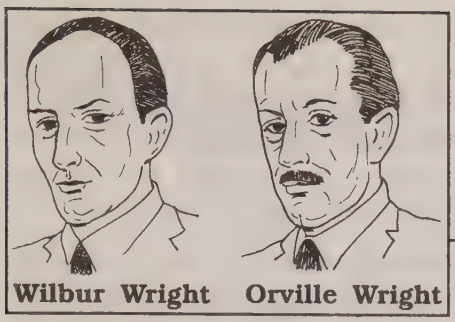
In 1903, the Curie couple shared the Nobel Prize for Physics with Henri Becquerel. The Curie couple had then become world famous. In 1904, Marie gave birth to their second daughter Eve. Life was looking up and things were moving smoothly. Tough days and despair had gone and the family was now comfortably settled. On April 19, 1906, Pierre Curie, while returning home after attending a meeting, was run over by a farm cart in the rue Dauphine in Paris and died instantly. Marie's world suddenly turned dark. But this spirited woman took up the responsibilities to fulfil Pierre's dream. As a special case, the French Department of Education appointed Marie as a professor in place of Pierre and honoured her. No woman was ever given such a high position by the university. Many turned jealous about this. She continued taking care of her family, while continuing her research and taught at the university simultaneously. She efficiently discharged all the responsibilities that she shouldered.

In 1910, she succeeded in isolating pure radium. In 1911, she was once again honoured with the Nobel Prize. It was for Chemistry this time. Madam Curie was the first person to receive this honour twice and that too in two different branches of science.



Cancer patient is treated by radium based radiation therapy

In July, 1914, Madam Curie fulfilled the dream of her late husband to establish a huge laboratory in Paris in his fond memory. Meanwhile, World War I had begun, so it could not become operational. Moreover, her colleagues were engaged in war duty. Soon after the war ended, the laboratory started functioning. On July 4, 1934, this spirited lady and first woman scientist to receive the Nobel Prize, breathed her last near Sallanches, France.



Wilbur Wright Orville Wright

47

Wilbur – Orville Wright

Wilbur Wright (1867 – 1912) and Orville Wright (1871 – 1948) are better known as the 'Wright Brothers', the world over. Wilbur, the elder of the two, was born on April 16, 1867 in Melville, Indiana, USA. Their father Milton Wright was an ordained minister of the Church of the United Brethren in Christ. Their mother was Susan Catherine Koerner. Milton Wright met Susan Catherine Koerner when he was training for the ministry, while she was a student at a United Brethren College in Hartsville, Indiana. In 1869, the Wright family moved to Dayton, Ohio State. They bought a small house there. Two years later, on August 19, 1871, younger brother Orville was born. After two years, their sister, Catherine was born. Their father was a priest in a local church. The Wright children did not receive any formal education, but could read and write.

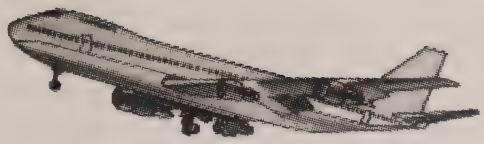
Wilbur and Orville enjoyed flying kites and loved watching birds fly. They always wondered whether it was possible for human beings to do the same. In this regard, they went through many books and also collected information they could lay their hands on. Orville loved to read the newspaper. This led him to be a newsperson at a young age. At 17, he independently published his newspaper. He was the writer, editor and printer of this newspaper. Soon it became quite popular and he asked Wilbur to join him as editor. The newspaper was going on well. Both became busy, but got ample opportunity to go through reading materials. They had a dream and it was

to soar in the sky. Meanwhile, their mother Susan passed away in 1889. In 1890, they came across the news of a German named Otto Lilienthal who had flown a glider. A glider has no engine, but the pilot balanced the aircraft by changing positions. This news encouraged the Wright Brothers to pursue making of their dream machine.

In 1892, the brothers opened a bicycle shop. Profits from the print shop and the bicycle shop eventually were to fund the Wright brothers' aeronautical experiments. Through trial and error they succeeded in their experiments and formed the basic principles of flying. They created a small air-tunnel in their bicycle store. They had developed more than 100 types of aircraft wings. They checked each of them and selected the best pair. They also observed that the birds controlled their movements in air by bending the farthest ends of their wings. So, they changed their wing design to aileron. They built their first glider and flew it as per their expectations. Thereafter, they built a lightweight four-cylinder, petrol driven engine with 12 horsepower. They wrapped velvet over a two-wing wooden structure and built an aircraft with 43 feet (approximately 9.3 metres) long wings.

The brothers were now confident of their success. They invited people to witness the first flight. They had organized the event at Kitty Hawk, near the seashore. They had arranged wooden planks under the aircraft. Orville took his seat in the cockpit. Wilbur pushed the aircraft on the planks. Soon, the aircraft took off into the air. It flew 100 feet high for 12 seconds and then safely returned to ground. It was Wilbur Wright's turn now. This time, the aircraft went higher up to 812 feet and stayed in air for 59 seconds. The Wright Brothers had realized their dream. Still, a lot more was needed to be done.

They decided to make an aircraft with a more powerful engine. To celebrate their success, the brothers joined the family for Christmas. Their father's blessings spurred



them further. They continued their experiments and made a more powerful engine that could fly up to one and half kilometres. They closed down the bicycle store and concentrated totally on their dream machine. It was also a time when similar experiments were being performed in Europe. Wilbur Wright visited France and impressed Frenchmen with his skills. He even took a government officer along for a ride. The ride lasted for an hour and four minutes.

Meanwhile, Orville continued his efforts in America. He also took the locals on trips performing experiments. He once flew an army officer. Unfortunately, the aircraft crashed and the army officer was killed. Orville sustained some injuries.

The Wright Brothers had become famous all over the world. A company contracted them to make aircraft. With money pouring in, they had become rich and famous. December 17, 1903, was a memorable day for the Wright Brothers. At 10.35 a.m. they took off on their maiden flight. It became the most memorable day of their lives when they wrote their names in history. The event was celebrated the world over. They had become rich and prosperous, but they were not content. Business did not hold them back. They wanted to experiment more. They restarted their research. Meanwhile, Wilbur died of typhoid on May 30, 1912. Around the same time the house they were building was complete. The grieving family had to move in without Wilbur. On April 3, 1917, their father passed away at the age of 89. Orville Wright was now president of the company. He had become an expert in flying aircraft. He died on January, 30, 1948, at the age of 77, in a Dayton hospital. The Wright Brothers became the first human beings to take to wings and because of their persistent efforts reached their goal and the world honoured them with many awards.

48

Robert Millikan

Every graduate student of physics learns about the classic experiment–Millikan oil-drop experiment to determine the electronic charge. The inventor of the experiment, the world-renowned scientist Robert Andrews Millikan, was born on March 22, 1868 at Morrison, Illinois, USA. He came from a family of less means, finance and a large family. Since childhood, he had to do odd jobs to help supplement the family income. The family condition forced all the six siblings in the house to contribute their mite or little earnings, before they could get any formal education.

In 1875, the Millikans moved to Maquoketa, in Iowa State. This small village with a population of 3,000 had 13 liquor bars. The village was known for its ruffians and thugs who frequented it. Yet, they stayed here for 11 years. The entire day revolved around the same routine as there was no avenue for them. Going to the gymnasium in the morning, helping the family in domestic duties, playing baseball and then a swim in the river were the kind of activities they indulged in. All such activities ensured that the three Millikan brothers became good body-builders.

There was a small village school which the brothers joined. The principal was a teacher of physics, but he was more interested in other activities than his subject. Hence, students too were not inclined towards physics. Millikan took a liking for the Greek language, literature and mathematics.

When asked at a school, "Are you ready to take up job as physics teacher?" he readily agreed out of necessity. He started burning the midnight oil to teach himself physics. Gradually, he picked up and started mastering the subject. He devoted his vacations to the study of physics. Students started attending his classes. The principal too, was pleased with the young man and offered him tutorship with a yearly remuneration of $600.

In 1891, he graduated from Oberlin. He also offered his services at the local gymnasium. Meanwhile, his professor recommended him for a fellowship at Columbia University. In the fall of 1893, he was awarded special fellowship. Here, he came into contact with geniuses like Professor Rood, Woodward and Pupin. Under their able guidance coupled with his perseverance, he received his doctorate in 1895.

At that time, America was far behind Europe in theoretical and applied physics. Physicists in Europe were engaged in various researches and in chemistry new vistas opened up. The term of Millikan's fellowship came to an end and he was not given any extension. On Pupin's advice, he took a loan of $300 and went to Europe to be part of mainstream research. During 1895–96, he stayed in Europe. It was a time when Becquerel had discovered radioactivity and was continuing experiments in that field. This training helped Millikan to become a good researcher, able administrator and also an excellent professor.

In 1896, Professor Albert Michelson invited Millikan to join his department as assistant at Chicago University. Millikan accepted the offer despite more lucrative offers from other places. He stayed on at Chicago University for 25 years and contributed his career's best research years. He was made professor in 1910. During his tenure the department of physics gained immense popularity and became the most important centre for study of physics in America.

Now that things were moving smoothly, Millikan reduced his teaching and concentrated totally on research. He carried out the oil-drop experiment and concluded that a tiny drop of oil measured to a thousandth part of a millimetre. Earlier, Sir J J Thomson had determined the charge of cathode particles (electrons). In 1909, he performed his famous oil-drop experiment to determine the value of the electronic charge. Millikan reanalyzed it and in 1912 he determined electronic mass with his experiments. He also verified Einstein's photoelectric equation and obtained a precise value for the Planck constant. His findings of electronic charge and Planck's constant were very accurate; the accuracy of which was not surpassed for several years.

Millikan was awarded the Nobel Prize for Physics in 1923 for his invaluable contribution in the research on the elementary (electronic) charge and the photoelectric effect.

In 1921, he left the Chicago University to join the Norman Bridge Laboratory of Physics at the California Institute of Technology, Pasadena and later, became its chairman in 1923. There, he made some initial studies of cosmic rays which were invaluable. He developed a special electroscope, which could be used for measurements on the most powerful cosmic rays. He held the post of chairman of the executive council of the institute until his retirement in 1945. It is to Millikan's credit that American research in physics got its due recognition. He trained and guided many future researchers, including C D Anderson who discovered positron.

In 1953, at the ripe old age of 87, Millikan passed away. He was one of the scientists who brought America to the forefront of research in physics and guided a young generation of scientists.

49

Lord Ernest Rutherford

Ernest Rutherford was born on August 30, 1871 in the southern island of Nelson, in New Zealand. His parents belonged to the Scottish farming community of England and had migrated to New Zealand in 1842. They were cultured and well educated.

In 1889, Ernest won a scholarship to Nelson College, a secondary school, where he was a popular boy. Another scholarship allowed him to enrol in Canterbury College, from where he graduated with a BA in 1892 and an MA in 1893 with first-class honours in mathematics and physics.

In 1895, Cambridge University announced scholarships for deserving students of British Commonwealth countries. This was a big break. Rutherford joined Cavendish Laboratory and started research. He was fortunate enough to get guidance from a genius like J J Thomson. It was the time when the sensational discovery of X-rays was just announced. This inspired Rutherford to work on it. Later on, he was attracted towards radioactivity. Thomson invited him to conduct research on the effects of X-rays on gases. Rutherford accepted the challenge happily and began the research. Thomson was already a world-renowned physicist and his assistant Rutherford was a brilliant researcher. Thomson considered Rutherford his best and most talented student. Rutherford concentrated on Becquerel's discovery of some mysterious and unknown rays. He found out that just as X-rays ionise the gases, these unknown rays (radioactive rays) ionise the gases.

Meanwhile, a new post of professor of physics was created at McGill University at Montreal, in Canada. Thomson could not think of a better choice than Rutherford for the post. He inspired Rutherford to join the place. Rutherford was reluctant to leave a reputed place like Cavendish Laboratory, but to satisfy his guide's desire he left for Canada in 1898. Here, he studied Becquerel rays under the effect of electric and magnetic fields. He made a wonderful discovery that these rays consisted of three types of rays, alpha, beta and gamma rays. He also succeeded in identifying two types: the radioactive rays that could be blocked by a thick paper were alpha rays (positively charged) and the ones that could be blocked by a thin aluminium foil were beta rays. Beta rays were negatively charged electrons. Besides, he came to know that gamma rays were very powerful like X-rays. Here, he got an opportunity to work with the great English chemist Frederick Soddy (Nobel Prize winner for Chemistry in 1921). Rutherford and Soddy then investigated three groups of radioactive elements–radium, thorium and actinium. They concluded in 1902 that radioactivity was a process in which atoms of one element spontaneously disintegrated into atoms of an entirely different element, which also were radioactive. This interpretation was opposed by many chemists who held firmly to the concept of the indestructibility of matter; the suggestion that some atoms could tear themselves apart to form entirely different kinds of matter was to them a remnant of medieval alchemy.

In 1907, Rutherford got an opportunity to return to England. There was a vacancy worth his calibre at Manchester University. He joined here and continued research in radioactivity. In 1908, Rutherford was awarded the Nobel Prize for Chemistry for his research on radioactivity and nucleus of the atom, though he was a well-known professor of physics. The British government

knighted him and he became Lord Rutherford of Nelson. He was thus honoured for his outstanding contribution in scientific research.

Another favourite student of J J Thomson, C T R Wilson was awarded the Nobel Prize for Physics in 1927 for his invention of the cloud chamber named after him. Rutherford used this equipment to study alpha rays more closely. He carried out many experiments on scattering of alpha particles by thin foils of metals. On the basis of his experimental results, he announced in 1911 that the nucleus of an atom contained all the positive charge, which caused the alpha particles to divert their path as they approached the nucleus. Rutherford was then hailed as the discoverer of proton, the positively charged particle in the atom.

It was Rutherford who discovered that an atom had a dense and massive positively-charged nucleus with the light negatively-charged electrons revolving around it. The simplest and lightest atom was that of hydrogen, with only one electron. In 1919, Rutherford proposed that the positively charged particle in the nucleus of hydrogen atom is a proton. These particles are present in the nuclei of all elements. The mass of a proton is 1836 times more than that of an electron. Like an electron, proton is also an elementary particle. Though proton is quite heavy than electron the electrical charge on both is equal but of opposite types. The mass of a proton is $1.6726231 \times 10^{-27}$ kg and proton's electrical charge is 1.602×10^{-19} coulomb.

Rutherford's celebrated students include Henri Moseley and Niels Bohr. It was thanks to the joint efforts of Rutherford and Bohr that the clear structure of the atom emerged.

In 1919, Rutherford was appointed the director of Cambridge University and chairman of Cavendish Laboratory. This was a memorable day for Rutherford as he had succeeded his guide J J Thomson. Thomson's another student James Chadwick discovered neutron in 1932, though Rutherford had predicted the existence of such a particle long before.

The 'Father of Proton', researcher of radioactivity, Rutherford died in 1937. He published about 80 research papers, winning respect, honour and medals, aptly to be called Lord Ernest Rutherford of Nelson.

50

Guglielmo Marconi

The renowned scientist and inventor of wireless communication Guglielmo Marconi, was born on April 25, 1874 in Bologna, Italy. He belonged to an affluent and cultured family, which provided him with the best of education. Marconi was a talented and polite child. Right since school days he carried out experiments and he preferred electrical experiments the most. He was allotted a room in his house which he converted into a laboratory. The room was scattered with wires, poles and tin containers. The enthusiastic youngster spent hours in this laboratory.

It was a time, when Scottish scientist James Clerk Maxwell's (1831–79) name was on everybody's lips. He had put forward the unified theory of electromagnetism, and the nature and propagation of electromagnetic waves. Before him, Faraday had discovered electromagnetic induction; a changing magnetic field could produce electricity in an electric conductor. Similarly, any change in electric field could produce a magnetic field. The electric and magnetic effects took some specific time to travel through air and vacuum. Maxwell had tried to gather information about electromagnetic waves and its propagation through mathematical equations. The speed of such waves was 1,86,000 miles (Approx. 3 lakh kilometres) per second. Such waves travelling through air or vacuum without passing through any wire were also called wireless waves.

When this discovery was being discussed in the scientific world, Marconi was just 15 years old. Once, he took his father into his small laboratory to demonstrate his experiments. He rang an electric bell fixed 15 feet away with such waves. His father appreciated his efforts saying it was a short distance and told him that he should try to cover longer distance.

Marconi continued his experiments with keen interest. He hung one wire in the air and buried another wire in the ground. He sent a wireless message up to a distance of about a mile. He felt that he had achieved something remarkable, but he also felt that the people of his country were not able to recognize his genius. So Marconi left Italy and arrived in London. He consulted an officer in the department of electricity and exhibited his findings. The officer was very much impressed with the work done by this young man and promised him all help.

Encouraged by this response, he arranged for a public demonstration of his experiments on the terrace of London's General Post Office. People applauded his innovative idea and London newspapers the next day were full of praise for this young Italian.

Professor Sir Jagadish Chandra Bose (1858–1937) of India, however, had already experimented on production and propagation of electromagnetic waves, in 1895. Bose was appointed professor of physics at the Presidency College, Kolkata (Calcutta). He had very limited means and facilities. But he used to make his own equipment out of the scrap available in market. He even had to spend his own money on these experiments. He carried out the experiment on production and propagation of electromagnetic waves in 1884. He demonstrated his discovery in the presence of the British Governor at Town Hall, Kolkata. The waves travelled a distance of 25 metres. A London periodical published two of his research papers. In 1895, he was invited by Royal Society to London, and

there he demonstrated publicly the production of electromagnetic waves relaying them through concrete walls. Thus, London had viewed these demonstrations even before Marconi showed them. Bose was invited again for demonstration in 1896, this time in the presence of great scholars including Lord Kelvin. London University awarded him the degree of Doctor of Science based on his research papers published earlier.

Jagadish Chandra, a simple man, never got his invention patented. Hence, the world did not take much notice of his important discovery. Soon, Marconi announced his invention and also secured the patent for the same. Marconi got all the credit for the invention as well as the Nobel Prize for Physics in 1909. Thus, Marconi came to be known as the pioneer of radio telegraphy.

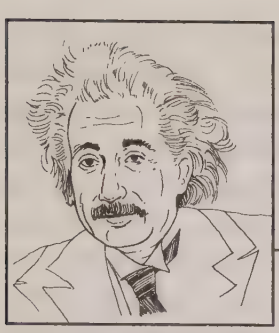
The news of this wonderful invention spread all over the world. The Government of Italy invited him to return home and promised all help required for his experiments. Marconi returned home and established a wireless station with the help of government grant. He could successfully send wireless messages to far away sailing naval war ships during the World War I. The Italian royalty also appreciated Marconi's arrangement. This also fetched him more financial help. He could strengthen his infrastructure which resulted in longer distance propagation of the wireless waves, even across the English Channel.

Marconi decided to establish a similar wireless station in Britain. He erected a 200 feet high tower. But before the station became functional, a cyclone razed the tower and other supporting poles to the ground. This did not dishearten Marconi. He decided to erect a 400 feet high tower and soon the wireless messages were transmitted in all the directions to a longer distance.

With his wireless waves, Marconi had served his motherland in World War I. Later on, he established his private and the world's first radio station at Chelmsford.

When Fleming invented the valve, radio receivers with valves were made available in the open market. And with the invention of the transistor after a few years the small transistor radio sets appeared in the market.

Marconi was financially very well-off now. Many nations and scientific institutions honoured Marconi soon after he was awarded the Nobel Prize. In 1929 the king of Italy honoured Marconi and his heirs with a pride of place in the royal court. Fortunately, his father Giuseppe lived to witness all these laurels won by his son. In 1927, 53-year-old Marconi married 23-year-old Countess Maria. Three years later Maria gave birth to a daughter. In 1933, the Marconi couple set out on a world tour. Marconi died in 1937. We cannot imagine a world without wireless today. Truly, the credit of enabling us to communicate rapidly through his invention of the wireless communication goes to none other than Marconi.



51

Albert Einstein

The world famous, greatest scientist of the twentieth century and the pioneer of the theory of relativity, Albert Hermann Einstein was born on March 14, 1879 at Ulm in southern part of Germany in a middle-class Jewish family. Within a year of his birth the family migrated to Munich. His father set up an electro-chemical plant and engineering works here. It was then that Uncle Jakob stimulated a fascination for mathematics and Uncle Cäsar Koch stimulated a consuming curiosity about science in Einstein.

Though he led an ordinary life, the child Albert in childhood, was unlike other children. He learnt to speak much later than the average period it takes for a normal child to speak. This worried his parents. He would rather lie down and daydream than play with other children of his age. He disliked physical strain. He even did not like playing any game. It was a time when Munich witnessed flag marches by the army. He did not like it. He actually detested the mechanical steps of the parading soldiers while other boys and youth enjoyed watching and even got inspired by it.

But he had an ear for good music. He inherited this trait from his mother, who was a Beethoven fan. He learned to play the violin at the age of six, a fond hobby which remained with him throughout his life. He liked to play the violin in his leisure or even when he wanted to relax.

Munich did not have public schools at that time. Different communities ran schools for the children belonging to particular faith. Albert's parents were religious but they were not fanatics. They admitted him to a nearby Catholic school. At 10, he went to secondary school known as Gymnasium where students were given pre-university training. They also taught some Jewish scripture. Thus, he received knowledge of both Jewish and Catholic faiths in his schools and knew the vices and virtues of both the faiths as well. Moreover, he never developed devotion for either. He even did not like the education system, especially, the rote learning and the compulsory physical training class.

Albert's uncle Jakob always encouraged him to study and helped him develop interest in algebra and geometry. When Albert was just 15 years old, his father faced financial problems in his business. They had to close down their electrical business and migrate to Milan, Italy. But Albert stayed back to complete his diploma at the Gymnasium. He loved mathematics so much that he did not pay attention to other subjects. This was reflected in his result. Besides, he disliked the physical training classes and thought of them as unnecessary. The strict discipline and tormenting teachers developed an intense dislike for the education system. He was finally rusticated from school to proceed to Italy to join his family.

Here, he got ample opportunity to ponder over his future. He decided to study mathematical physics. He appeared for the entrance test for the Swiss Federal Polytechnic School, Zurich, in Switzerland. But he failed. He scored well in mathematics, but could not make it in languages and biology. But the principal was very much impressed by his performance in mathematics and helped him get admission in the school as Einstein was a bright and promising student.

He realized that the education system was much better here than in Munich. The teachers always encouraged the students and more than any thing else, he did not have to attend compulsory physical training classes. He enjoyed being here. He loved the discussions on various subjects and always participated in them. For the first time in life he was eager to go to school. He took up study to be trained as a teacher of physics and accordingly, selected his subjects. He completed his study in a fine manner.

He had to undergo financial difficulties, as his father could not provide for his education due to business failure. Fortunately, one of his well-off relatives took up the responsibility of paying for his education and boarding and finally, he was able to complete his university education.

Einstein was a brilliant student. He carried the best of opinions and recommendations from his teachers and professors, but failed to get a teaching job. This was a big disappointment for him. He realized that to survive, he needed a job to earn money from. He started working at the Swiss Patent Office at Berne. In his leisure he continued his study of mathematical physics through self-education and research.

Meanwhile, Hitler and Nazism had become powerful in Germany, making life difficult for the Jews. Jews were massacred in large numbers and impediments were created in their work. It was unsafe to live at places where the Nazi concentration camps were located.

During his tenure at the Berne patent office, he proposed the world famous Theory of Relativity in 1905. The theory later helped to build a nuclear bomb. At that time, Sir Isaac Newton and his laws of motion were at the forefront of the scientific world. They were widely accepted. Newton had formulated his theory some two and a half centuries back and it had satisfactorily provided answers to many questions in physics.

Einstein's theory of relativity revolutionized physics. According to age-old rules of physics, it was an accepted fact that matter can neither be produced nor destroyed. Einstein discovered that matter can be converted into energy and vice-versa. Einstein's finding is summed up in an equation '$E = mc^2$' where E = energy, m = mass of the matter and c = the speed of light, where $c = 3 \times 10^8$ m/s in vacuum. This is the most famous equation in physics. This equation made it clear that a little quantity of matter is capable of producing massive energy if it is processed in a particular way.

His contemporary, German scientist Max Planck had about 100 years back in 1900 propounded the theory of light as quantum theory. But the world was not ready to discard the age-old theories. Scientists did not readily accept Planck's theory. Einstein used Planck's quantum theory to explain the photoelectric effect. Along with the quantum theory, the scientists were attracted towards his theory of relativity as well.

At that time, Sir Ashutosh Mukherjee, father of one of our national leader late Shyamaprasad Mukherjee, was the vice-chancellor of Kolkata (Calcutta) University. He was a retired high court judge, but mathematics was his favourite subject. He had contributed immensely to develop the department of science at the university. The great Indian scientist Satyendra Nath Bose was his student. Bose was offered lecturership at the same college when he topped the MSc class at the university. When the theory of relativity was announced, Mukherjee introduced it as a subject in the post-graduate course at the university and encouraged Bose to study and teach it too. Later, with Einstein's permission Bose translated the research papers on the Theory of Relativity from German to English and got them published from the university. Einstein congratulated Bose for his accurate translation. In 1924, when Bose was visiting Europe for further research, he

personally met Einstein and thanked him for granting permission to translate his work. Einstein too expressed his pleasure for the excellent translation by Bose. Einstein put forward the general theory of relativity in 1915. According to this theory, rays of light should bend while passing near a massive star. This was verified by Eddington in 1919 during a total solar eclipse.

Once Einstein's Theory of Relativity was announced and as his research papers started getting published, the world's scientists after thoroughly going through them put their stamp of approval. World had now come to recognise and accept the genius in him. In 1909, he was appointed junior professor at Zurich University. Thereafter, he joined the German University at Prague. After serving there for some time he returned to Zurich University as a professor in 1912. He was invited to Berlin University and also visited England and America on invitations from various institutions. Meanwhile, Nazis came to power in Germany. Soon, Einstein's home and property were seized.

Einstein accepted directorship of the newly established institute for mathematical studies at Princeton, New Jersey, USA. He also accepted American citizenship. He was pained by the Nazi brutalities and atrocities towards the Jews. In America, he openly favoured an independent nation for the Jews. In fact, he was a true supporter of a united world government.

In the fall of 1939 in a personal letter to the then American President Franklin Roosevelt, he wrote warning that soon German scientists would be able to turn uranium into a massive source of energy with a capacity to destroy the world. One such bomb would be enough to destroy a big city or port. He requested the American President to sanction a project to counter the German bomb. As per his prediction, exactly 6 years later, on August 6, 1945, America dropped an atom bomb on Hiroshima in Japan. About 60,000 people died instantly, 1,00,000 people were

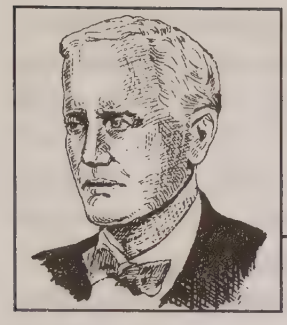
seriously injured and about 2,00,000 people lost their homes. Some 6000 houses were razed to the ground. Another such bomb was dropped three days later, on Nagasaki in Japan. Japan surrendered immediately and the World War II ended.

When an independent Jewish state, Israel, was formed at the end of the World War II, Einstein was invited to head the nation. He politely turned down the offer saying that he could only help solve problems related to science. He modestly added that he was unable to solve problems related to human beings and humanity, at large.

Einstein was awarded the Nobel Prize for Physics in 1921 for his research on photoelectric effect. After putting forward his general theory of relativity and publishing papers in cosmology, he spent many years trying to develop a unified field theory combining gravity and electro-magnetism. He did not succeed and no one else has succeeded so far.

Einstein was a foremost opponent of the deadly weapons of mass destruction like the atom bomb. He shuddered and felt guilty when he came to know about the destruction it had caused in Japan. He too was responsible for this destruction. He had thought his invention would be for the betterment of humanity. He even corresponded with Gandhiji, the apostle of non-violence, on this issue.

This messenger of peace and a great scientist bade farewell to the world on April 18, 1955 at Princeton. He regretted and was pained by the misuse of atomic energy till his last breath.



52

Sir Alexander Fleming

The discoverer of an invaluable and great antibiotic penicillin, Sir Alexander Fleming, was born on August 6, 1881 in a farmer family at Lochfield, Ayrshire, Scotland. He was the seventh among eight siblings. When he turned 7, his father Hugh Fleming died and all the domestic responsibility fell on his mother Grace's shoulders. Mentally strong, she took pains to tend the farm and reared all her children with love and affection.

Till the age of 10, Alec studied at the nearby Loodun Moor school. Then he was admitted at the Darvel School where his elder brother studied. He would walk the four mile distance to the school located on a hillock every day. Climbing up and down the hillock daily, gave him an opportunity to observe the beauty of nature. He thus became a nature lover and took keen interest in studying its different aspects. Two years later, at the age of 12 he joined the Kilmarnock Academy.

His elder brother Tom had then completed his study in ophthalmology and opened a dispensary in London. At 14, Alexander left Kilmarnock Academy school. He went with his two elder brothers John and Robert for London to join his brother Tom. John and Robert together learnt the art of manufacturing eye glasses to become opticians.

Financially, the family was still not well-off. For this reason Alexander had to interrupt his further studies. He got a job at a shipping company when he turned 16. In 1901, the wheel of fortune turned for good when they

inherited some money from an uncle. Alexander resumed his education and joined London's St Mary Medical School. He concentrated totally on his study and stood first in all the subjects year after year.

He also participated in various sports and excelled there as well. A respected student in school, he stood first in pharmacology, physiology and pathology, bagging all the medals. At sports, he displayed excellent sporting skills in shooting, swimming and water polo.

In 1906, at the age of 25, he graduated from St Mary Medical School and started working as research assistant to Dr Olmroth Wright. Wright was not only a renowned microbiologist, but a specialist researcher as well. He had earned fame by conducting specific researches. Louis Pasteur had discovered that there are microbes present around us and within us. They enter our body through respiration or drinking water. Wright conducted further research in this field. He discovered that white blood corpuscles weakened these microbes under certain conditions and sometimes destroyed them completely. He called this characteristic of a blood cell Opsonin.

As a result of this discovery, a new method of treatment came into practice. Earlier, doctors used to diagnose the patient by listening to his heartbeats and on the basis of his complaints. Now, they examined the blood sample of the patient under the microscope and diagnosed the disease according to the presence of microorganisms in blood and then prescribed treatment to the patient.

On February 13, 1922, the Royal Society of London received a research article submitted by Fleming titled 'A Remarkable Bacteriolytic Element found in Tissues and Secretions'. It was about the discovery and isolation of a new natural enzyme called lysozyme.

During this time Fleming suffered from bad cold and had trouble breathing. He experienced that a single drop of lysozyme could cure him completely. He noted that

lysozyme was present in certain body parts, tears, saliva and muscle cells. He even discovered lysozyme in egg white, cow milk and in mother's milk. He declared that lysozyme is an antibiotic that kills bacteria and it is present in almost all living organisms. Thus, nature has equipped us to protect ourselves.

On a summer afternoon in 1928, Fleming picked up a glass vessel whose lid was left open by mistake at the laboratory of St Mary's Hospital. He had prepared a grapelike fungus producing bacteria clusters of staphylococcus. He observed that it had rotted and had a green-coloured fungus growing on it. But what caught his attention was a ring surrounding that rotting area. This ring shaped area was free from bacteria. He concluded that the fungus in this area held the power to destroy the bacteria. Green-coloured fungus with looks of a brush was named penicillium.

Fleming began a scientific inquiry of this fungus. Initially, it was grown on a solid substance. Later, he

Penicillin producing fungus as observed under the microscope

successfully grew it in liquid medium too. He saw that this fungus had phenomenal power to kill certain types of bacteria. He also examined and discovered that this fungus was not harmful to human cells. He experimented on rabbits and rats and successfully confirmed the fact that penicillin was harmless to living bodies. His progress in this direction was adversely affected by lack of funds. Further studies was hampered due to it.

During this time Dr Ernst Boris Chain and Professor Howard Walter Florey had just finished research on lysozyme. While they were about to begin research in a new field, they came across Fleming's report on penicillin in 1937 and decided to carry out research on it. They were able to produce this fungus chemically and successfully experimented it on animals. They felt that time was ripe to test the drug on humans. Finally in 1941, they tried it on a patient suffering from septicemia. Earlier, doctors had given sulphur drugs to him, but they were ineffective. There was no chance of survival of the patient. The patient was injected 200 mg penicillin and then 100 mg was injected every hour. Within a day his condition had visibly improved. But they did not have sufficient penicillin and the patient died. It was an unfortunate event, but other doctors who were present were sure that penicillin could have saved the patient if it had been available in adequate quantity. Thereafter, a couple of patients treated with penicillin were cured completely.

In 1941, Britain was engaged in World War II. Local pharmaceutical companies were not ready to risk mass production and marketing of this new medicine. Howard Walter Florey went to America and explained the importance of this new medicine to the pharmaceutical companies there. Initially, he inspired and convinced them to produce sufficient penicillin for the war needs. Later, when people came to realise the importance of this wonder drug that could save lakhs of lives, work began in right earnest to manufacture it. In 1943, the production of penicillin was

done on a large scale. The entire stock was to be used for injured soldiers.

Penicillin as a drug proved to be unique. Fleming's new remedy instantly gained popularity and made its inventor world famous. Many incurable diseases could be cured now. Many lives were saved. People were grateful to Fleming and expressed their gratitude with personal letters to him, calling him 'messiah'.

The British Government knighted him in 1944 and he became Sir Alexander Fleming. He was awarded the Nobel Prize for Physiology or Medicine in 1945, 17 years after the discovery of penicillin. He shared the prize with Howard Walter Florey and Ernst Boris Chain.

Besides the Nobel Prize, Fleming was honoured with several other awards. The Americans expressed their gratitude by collecting and presenting $1,00,000 to him. Fleming politely returned the money saying that he would be happy if the fund was used to develop the laboratory at St Mary Hospital. This great man even rejected the idea of patenting penicillin in the interest of humanity that would have earned him millions. Sir Alexander Fleming left this mortal world on March 11, 1955. Even today Fleming is remembered as the 'Father of Penicillin'.

53

Irving Langmuir

Irving Langmuir was born on Jan. 31, 1881 in Brooklyn, New York, USA. His elder brother Arthur played an important role in Irving's progress. When Irving was nine years old, to sustain his interest in science, Arthur thought of setting up a small laboratory for him.

At the age of 11, Irving joined school in Brooklyn. Within a year, his father was transferred to Paris and Irving had to be admitted at a French boarding house in Paris. He loved the school as he could spend as much time in the laboratory as he wanted to. When his father was transferred back to America, he took admission at Pret Institute of Brooklyn where Arthur was an instructor. Besides, he worked in a factory as a chemist. Irving started living at his brother's place then.

Under such favourable environment he was able to gain more knowledge. He excelled in chemistry and calculus. He used to read all available science magazines and books. Though he lost his father at 17, he never faced any financial problem. In 1899, at the age of 18, Irving got admission in Columbia College. Here, students were given special training related to mine industry. Irving received training as a metallurgical engineer. For further studies, he again went to Europe to study at Gottingen University, Germany for three years.

On completion of his studies, Irving was appointed as professor at the Technical Institute in New Jersey. He had a few other offers, but preferred this institute as he would

have the freedom and additional time for conducting research.

During the summer vacation of 1909, he got an excellent opportunity to carry out research. A newly established laboratory at New York invited Langmuir for research in the vacation batches and he happily accepted it. Here, he got an opportunity to study tungsten wire used in the electric light bulb. This wire had a short life span as it would burn out very fast. Langmuir conducted research to find the reason behind it. The vacation came to an end, yet he was unable to complete his research. He was requested to continue at the institute as a staff member till the research was over. He accepted the invitation and also got the permission to conduct research on other independent projects simultaneously. Here, he proposed the concept of 'Pure Research' which was readily accepted. The vice president in charge of research at the General Electric Laboratory, Willis Rodney Whitney was a visionary. He recognized the importance of Langmuir's research and readily cooperated.

Langmuir devised a special mercury vapour pump, which could suck out all the air from a bulb, producing a high vacuum in it. He also discovered that some inert gases like argon did react with hot tungsten. The tungsten wire could now be used for longer time. If inert gases like nitrogen or argon were vacuum packed in a tungsten wire bulb, its life could be further extended. This discovery was beneficial to both, the bulb manufacturing companies and the customers.

During the same period Langmuir announced another invention – atomic hydrogen torch. He observed that at a very high temperature, i.e. at the melting point of the tungsten wire, hydrogen atoms got separated (fission). Moreover, when these atoms were reunited (fusion), energy was released. Based on this principle, Langmuir developed the atomic hydrogen torch in 1927. One could weld metal

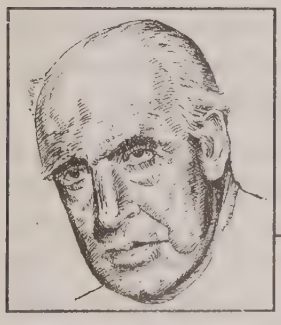
at the temperature of 6000°C with this torch which made welding job comparatively easy.

Even after such a great success, Langmuir was not satisfied. Now, he wanted to know why some elements like argon and helium were inert, while elements like hydrogen and chlorine were active. He began study of the structure of an atom. He possessed sound knowledge of chemistry, physics and mathematics. The atomic number of hydrogen is one. One electron revolves around its nucleus and this orbit is incomplete. The atomic number of helium is two and two electrons revolve around its nucleus in an orbit and the orbit is complete. Neon, the gas on which Langmuir had worked a lot, was an inactive or inert gas. Its atomic number is ten. It has two electrons revolving in an orbit closer to the nucleus and eight electrons revolving in an orbit away from the nucleus. Neon is inert. The atomic number of Chlorine is seventeen. Out of seventeen electrons two revolve in the first orbit, eight revolve in the second orbit and the remaining seven revolve in the third orbit. The third orbit is incomplete. Chlorine is active because it tends to accept an electron to complete its outer orbit. Atoms of hydrogen and chlorine can share one electron from their outermost orbit. This is the reason why hydrogen easily combines with chlorine to produce hydrochloric acid. Langmuir's findings about chemical activity were accepted all over the world. He was awarded the Nobel Prize for Chemistry in 1932. He was the first to use the terms electrovalence and covalence.

He studied various other aspects. He studied certain chemicals for their colours and other external features, a study known as surface chemistry. His studies led to answers to certain basic questions like why certain substances dissolve in water and others do not, why some atoms float on the surface while others sink. His study helped in understanding of some features of catalysis.

The General Electric Company appreciated Langmuir's work and appointed him Vice-chairman of the company. He would travel abroad during the summer vacations with his family. At work, he spent every moment in research. Thereafter, he also carried out research on the weather and artificial rain. He would create artificial rain in a limited area by sprinkling silver iodide over the clouds.

He retired in 1951, but continued as a guide and adviser to the company as well as to the government. He died in 1957. He spent all his life for the world of science. Apart from the Nobel Prize, he was awarded and conferred upon several other prizes and honours by many scientific institutions.



54

Niels Bohr

The man to present the first ever model of an atom, the fount of knowledge, Niels Henrik David Bohr was born on October 7, 1885 in Copenhagen, Denmark. His father Christian Bohr was a professor of physiology at Copenhagen University. His mother Ellen Adler Bohr came from a wealthy Jewish family prominent in Danish banking and parliamentary circles. Niels was born in his maternal family home in 'King Georg's Palace', considered to be one of the prominent and majestic private homes of Copenhagen.

Niels had primary, secondary and university education in Copenhagen. He was a brilliant and industrious student.

He and his younger brother Harold were good football players. They were proud members of the Danish football team. In the Scandinavian state too, they were considered as leading players. It is said that if you ask a Danish citizen about his pride in the four best things of Denmark, he would say: its prosperous shipbuilding industry, her prosperous dairy and cheese industry and her two prodigious sons – the famed artist Hans Christian Andersen and country's greatest scientist Niels Bohr. The Danish Science Society had awarded a gold medal to Bohr for ingenious study of surface tension. His brother Harold became a great mathematician later.

In 1911, Bohr completed his doctorate in physics. Then he went to London and under the able guidance of Sir J J Thomson, the 'Father of Electron', he started research at the Cavendish Laboratory. He then worked with Ernest Rutherford at Manchester for about four years. They remained good friends throughout their lives. Bohr even named his son Ernest after his dear friend.

In 1913, Bohr presented his basic theory of the internal structure of an atom. Later, it underwent lot of changes and transformations over a period known as Bohr's atomic model or Bohr's theory of atom. This theory became very useful in the fields of chemistry and atomic science. Thanks to this theory that today so much development has taken place in the field of atomic energy.

An atom is the smallest particle of an element that exists freely and takes part in a chemical reaction. Atoms of same or different elements combine to form molecules. Molecules form a solid or liquid or gas depending upon the intermolecular strength or force and conditions like temperature and pressure.

An atom is made of two parts. Its core is known as nucleus which contains all the positive charge in the atom and almost all the mass of the atom. The electrons move at high speed in circular orbits around the nucleus. This

is known as Bohr model of the atom. It can be compared to the solar system. In the solar system, the Sun is at the centre and the planets and asteroids revolve around the sun in the specific orbits. Atom is very small. The diameter of atom's nucleus is supposed to be 1,00,000th part of an atom's diameter. Electrons revolve around it at high speed.

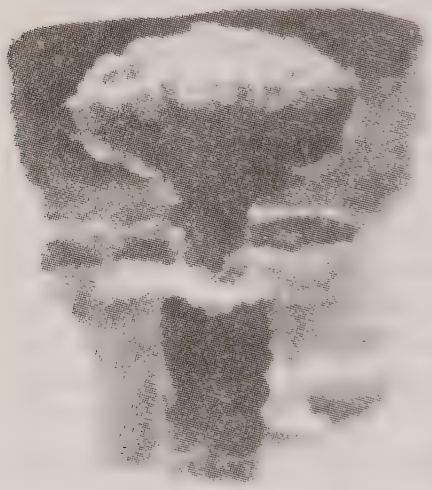
Hydrogen is the lightest element among all the natural elements. Its nucleus contains only one proton. It carries positive charge. An electron is electrically equal–same as that of the proton, but negative in charge. A proton is 1836 times heavier than an electron. In the hydrogen atom there is only one proton with one electron. The next lightweight element is helium. Its nucleus has two protons and two neutrons. Two electrons move around the nucleus. Uranium is the heaviest of all natural elements. It has 92 electrons, which revolve in 7 different orbits around the nucleus. Thus, in each element the number of protons and neutrons differs.

Bohr, with the help of his atomic model and Planck's quantum theory, was able to explain the stability of the atom and the origin of atomic spectra.

Normally, electrons revolve in their own assigned orbits in an atom. But when electricity or energy is passed through an atom, the electrons quickly change their orbits and jump into a higher orbit. It returns to its original position in a short while. When electron moves to higher orbit it consumes energy and on its return, it releases energy. This release of energy is normally in the form of electromagnetic radiations. Bohr determined the atomic structure of matter by calculating the wavelength of the radiation produced during this process.

Bohr's work provided a major breakthrough in atomic physics. It dawned a new era in science. Bohr received the Nobel Prize for Physics nine years after his wonderful discovery, in 1922. At 37 years of age, he was the youngest physicist to receive this honour. Prior to this achievement,

he was appointed chairman at the Copenhagen based Institute of Theoretical Physics. In a small country like Denmark, scientists from all over the world would gather at Copenhagen due to Bohr. Einstein had spoken the truth when he asked as to what would have been the state of atomic knowledge, had Bohr not been there.



Atomic bomb explosion

In 1939, a young Austrian Jew lady, Lise Meitner and her nephew Otto Robert Frisch came to Denmark from Nazi-infested Germany. They were appointed as researchers at Bohr's institute. They drew Bohr's attention to an article announcing that German scientists were working on their latest inventions and were planning to divide the nucleus of uranium into two equal parts. Bohr saw that if this was made possible, then immense energy could be produced during the process. It was also possible that Germans could use this technology to be powerful enough to destroy the world. Bohr rushed to America with this information. He discussed and deliberated on the issue with scientists Albert Einstein and Enrico Fermi. Fermi was working on this subject at Columbia University. It did not take much time for these eminent scientists to realise how dangerous it would be for the future of the world. The picture was very clear in their minds. Thereafter, America produced atom bombs and dropped them on two Japanese cities, Hiroshima and Nagasaki, to end the World War II.

Bohr immediately returned to Denmark after deliberations in America. In April 1940, Germany attacked

and captured Denmark, sending the king behind bars and stripping the army off weapons. They had planned to kill 6,000 Jews living in Denmark. But about 5,000 of them safely sailed to Sweden, thus failing the German plan. Niels Bohr, the son of a Jewish mother and his wife Margrethe Norlund were rescued in the dead of night, by the Danish resistance movement in a fisherman's boat to reach Sweden safely. Nazis raided Bohr's residence, but fortunately, they could not lay their hands on the gold medal awarded as the Nobel Prize. Later, Bohr reached America and joined his son Aage, then working as a research physicist at Los Alamos in a nuclear project.

Bohr returned to Copenhagen after the end of the World War II. He was deeply saddened by America's attack on Japan. He advocated ban on nuclear explosion at international level. Bohr attended the peace conference at Geneva in 1955 as chairman of Denmark's Atomic Energy Commission. He was elected chairman of the conference. In October 1957, Bohr received the $75,000 Atoms for Peace Award from Ford. Bohr received the highest number of awards and medals in the world of science.

Among his other researches, his work on the liquid drop model to explain nuclear properties and the principle of complementarity have played an important role in the development of modern physics.

In his last years Bohr tried to point out ways in which the idea of complementarities could throw light on many aspects of human life and thought. He had a major influence on several generations of physicists, deepening their approach to science and to their lives. Bohr himself was always ready to learn. He drew strength from his close personal ties with his co-workers, his sons, wife and brother. Profoundly international in spirit, Bohr was just as profoundly Danish, firmly rooted in his own culture. This was symbolized by his many public roles, particularly as president of the Royal Danish Academy from 1939 until the end of his life. He died in Copenhagen on November 18, 1962.

55

John Logie Baird

The inventor of the television, John Logie Baird was born on August 13, 1888, at a hamlet Helensburgh, Dunbarton, near Glasgow, Scotland. Son of a Scottish engineer, he became the first man to televise pictures of objects in motion. The youngest in the family, John was of weak constitution and often remained ill, especially afflicted with cold. This affected his study. He did not have any particular interest in reading. His only interest was photography. He was a member of his school photography club. Boys took photographs all by themselves. The club held a monthly competition wherein the best photograph among those clicked by the students was awarded a prize.

John had another interest too. He conducted experiments using electric wires. He had a particular interest in telephone. He had even linked a telephone line from his home to his friend's house at some distance and both would talk for hours on this indigenous phone line. On one particular stormy night the wires broke off, and got tangled and coiled around the neck of a passerby. Luckily, the man was saved, but John got the scolding of his life and thus ended this saga.

As he grew up, his electrical experiments increased. Once, he thought of creating diamonds. He thought out a formula and collected the required material, some of it explosive in nature. But the volatile explosive material suddenly caught fire resulting in a blast. Though he was saved, he vowed never to do such dangerous experiments.

With a view to be an engineer, Baird took up a job at an electricity company. He realized that he had to earn

his bread. But he was not much comfortable at his work. One day he was so severely struck by bad cold that he was confined to his bed. To keep himself warm, he wrapped papers on his feet. It worked. This triggered him of an idea to make socks. He bought necessary things the next morning, dyed the cotton yarn in various colours and made colourful socks. He went to a shopkeeper and showed his creation. The shopkeeper bought all the socks and asked him to supply more. Soon, Glasgow dwellers were using this innovative creation of Baird. Later, he employed people for mass production of socks.

He was once again down with severe cold and illness. The doctor advised him to stay at a place with warmer climate. He decided to go to West Indies. He was happy with the prospect of the extended market for socks. But the shopkeepers in West Indies did not show any interest in his socks. He was unable to sell even a single pair of socks. His ever creative mind thought of something else. West Indies had many orchards of lemon, orange and sugar cane. He thought of a pickle factory and soon started production with the help of a friend. Baird discovered to his horror that the sugar and the sweet aroma of pickles attracted some poisonous insects in the area. They even bit Baird. His health further deteriorated and he returned to London.

The cold climate of London did not suit him as it was very cold there and the doctor advised him to move near the seashore. This worked. On a pleasant evening, while he was taking a stroll on the beach, he heard a song on radio playing at a nearby hotel. Suddenly it struck him: sound could travel far through waves. He wondered if it was possible to send visuals the same way. He started working on this concept. He collected the required material: wires, an empty trunk, batteries, empty cookie tins, bicycle headlight, candle, etc. He worked continuously for days experimenting on the contraption. Finally, he could produce

a blurred picture on a screen in his room. Now, he worked hard to obtain a clearer picture. When his landlord came to know about his experiments, he threw him out. But he was undeterred. He returned to London and worked even more enthusiastically. After many days, he succeeded in producing clear images on the screen. Coming to know the experiment and its results, people started dropping at his residence, taking keen interest in his work. Once, Baird made a boy stand in one room and showed his image on a screen in another room. He could even show the movements of the boy clearly on the screen. He was extremely delighted with his success.

He invited scientists and journalists for a demonstration. They appreciated his work and congratulated him for his invaluable invention. Soon, the world knew about Baird and his invention. Initially, the pictures appeared blurred, but soon they became clear. He even succeeded in relaying coloured pictures. Now, he started relaying opera and theatre on his television.

He even started work on developing a television set. Despite employing many people he was unable to meet the public demand. In fact, he had envisioned a television station on the lines of a radio station. But commencement of World War II marred his plans. Besides, his relay station was also bombarded and destroyed. Meanwhile, he progressed towards the broadcast of colour pictures.

Once again he was struck by a bout of severe cold. This time it was life threatening. He left the experiments midway and returned home. On June 14, 1946, at Bexhill-on-Sea, Sussex, England, this television pioneer left for his heavenly abode. Thus, after presenting the world with the wonderful gift–television, the 58-year-old John Logie Baird bid adieu.

56

Sir James Chadwick

James Chadwick, the discoverer of neutron, a constituent of the nucleus of an atom, was born in Manchester, England on October 20, 1891. He was the eldest son of J J Chadwick. After completing his schooling from the local school he joined the famed Victoria University in Manchester. He acquired his post-graduate degree in 1911. He received a scholarship and went to Charlotenberg, Germany for further study in 1913. Chadwick studied under Hans Geiger at the Technische Hochschule, Berlin. When the World War I broke out in 1914, the Germans captured him and sent him to a labour camp. There was some solace when he met some scientists there and discussed problems in science with them. Thus, he continued his studies mentally on the subject of his interest. When the war ended, he returned home in 1919.

Around the time of his return to Manchester, Lord Rutherford had for the first time made it possible to separate hydrogen and oxygen through artificial transformation. He worked with Rutherford for a while and then got on with his research. But in 1921, when Rutherford succeeded Sir J J Thomson as professor of physics at Cavendish Laboratory, he invited Chadwick to join him. Chadwick accepted it happily. First of all, he completed his thesis and submitted it to the University. In 1921, he received doctorate from Cambridge University. He took up lecturership at Cavendish Laboratory and also assisted Rutherford in his research. What happens if the nucleus of an atom of an element is bombarded with high

energy alpha particles? Can some new element be found out by doing so? He got down to solving these mysteries. He also wanted to know the structure and size of the nucleus. In 1922, Rutherford and Chadwick discovered 'proton' when they bombarded alpha particles on nitrogen nucleus. In 1925, Chadwick married Eileen Stuart Brown of Liverpool. The same year he was appointed assistant director at the laboratory.

In 1920, scientist Williams Hawkins had predicted the presence of a neutral particle in a nucleus. Many years later, Chadwick discovered this particle called the neutron. For this, Chadwick was awarded the Nobel Prize for Physics in 1935.

During the same year, he resigned from Cambridge due to difference of opinion with Rutherford on building a new device called cyclotron. He then joined Lavon Jones Institute in Liverpool University as professor and built the first cyclotron in UK. In the wake of World War II in 1939, it was decided to bring both British Atomic Project and America's Project at Manhattan together. In 1941, as part of the British Project, he joined the Tube Alloys Project. Two years later, he went to America. He became the scientific advisor to the American-British-Canadian Policy Committee at Oakridge. He was also associated with Robert Oppenheimer's team working at Los Alamos, New Mexico, USA. This team was working to produce an atomic bomb to end the war. July 16, 1945 was set for the test of the atomic bomb. The bomb was planted on a 32-ton 100 feet tower erected at Gyro Hill–Alamogordo air base in the desert 120 miles southeast of Albuquerque, New Mexico. At 5:30 in the morning, at a control room, 9 miles (14.5 kms) away from the site, in the presence of about 100 scientists a robot pressed the button. An immense fireball rose in the air. The blast was so loud that it was heard 450 miles away in Texas. The smoke covered the area of 7 miles. The tower had melted with the heat energy

produced. The test was declared successful and the scientists' job was over. On August 6, 1945, the first atom bomb was dropped on the Japanese city of Hiroshima. In a short while, around 6,000 people were killed, 40,000 were rendered blind and 20,000 gradually became the victims. The entire city had turned into a big graveyard. The second atom bomb was dropped on Nagasaki on August 9, 1945. Japan immediately surrendered and World War II came to an end.

Many atomic scientists believe that such use can only cause mass destruction and unhappiness. Scientists believe that this demon can be tamed and used constructively, to make life happy and prosperous in this world.

By 1945, Chadwick was known all over the world as an extraordinary, cultured and self-possessed man. He was also known as a calm, composed and selfless scientist. The British government conferred knighthood on him and appointed him the National Science Advisor. He also served as the British representative to the American Atomic Energy Commission.

Besides his being awarded the Nobel Prize in 1935 for the discovery of the neutron, many international universities and scientific institutions honoured him. In 1946, he received the Merit Medal of the USA. In 1950, the Royal Society of England conferred on him the Copley Medal, Franklin Institute, Philadelphia awarded him the Franklin Award. The American Physics Society and other reputed institutions offered him honorary membership. Since 1957 he was associated with the United Kingdom Atomic Energy Institute as part-time member.

Many reputed science periodicals and journals published his articles and research papers. He also wrote on radiation in several magazines and reputed newspapers. These were very informative and useful for scientists, science teachers and the public, at large. In 1930, in collaboration with Lord Rutherford and Sir Charles Ellis

he wrote a reference book titled 'Rays Emanating from Radioactive Substances'. The revised edition was published in 1933.

On July 24, 1974, at Cambridge, Cambridgeshire, England, this great scientist passed away at 84. May his invaluable contributions be used for constructive purposes in this world. It is only the future that can reveal whether this discovery of nuclear energy would be beneficial or detrimental to the world.

57

Arthur Compton

Arthur Holly Compton was born on September 10, 1892, at Wooster, Ohio, USA. His father Elias Compton was professor of philosophy at Wooster College, Oxford, in Ohio, and also served as priest in the church there. Arthur, the youngest of three brothers and a sister, was brought up in religious atmosphere at home. His sister Mary married a missionary. They worked and settled in Allahabad, India.

Arthur's eldest brother Karl Compton was a physicist, who had written many papers. Besides, he had done considerable research on photoelectricity and the crystal structure. He was appointed president of the Massachusetts Institute of Technology (MIT). Another brother, Wilson Compton, gained reputation as a good economist and able administrator.

Their mother, Otelia was a doting mother and had raised the children with utmost care and attention. She was their guide and toiled for her children. She was aware of her children's activities and took care to ensure that they did no wrong. The children too reciprocated and were aware of her contribution in their progress. Probably this was the reason that in October 1932, Wooster College of Ohio honoured 74-year-old Otelia Compton as the best mother. In presence of her three sons and husband, she was conferred the honorary degree 'Doctor of Law'. She was proud of her three sons, who had made important contributions in their respective fields towards the progress of the country and the development of the world.

Compton was curious about science from an early age. Initially, he developed interest in aeronautics. He had studied deeply the theories and practical aspects of airplanes. He had even constructed and flown a glider. But later, he was attracted towards astronomy. He had another interest. He would attend any lecture by experts in the town and try to understand it. With his homebuilt telescope he would stargaze for nights together and note his observations. He would photograph the planets and then study them. Actually, he was following Karl's footsteps. All three Compton brothers graduated with honours from Wooster College and earned their PhDs from Princeton University. They were all good athletes in college.

When Arthur was a college student, he had invented the gyroscopic technique to control an aircraft and got it patented. He wanted to study mechanical engineering, but when he saw Karl opting for mathematics and physics, he discussed it with him and finally decided to follow him. He got his doctorate in 1916. He worked as instructor in physics at Minnesota University for a year. Then he joined Westinghouse Corporation at Pittsburgh as research engineer. During his two-year service, he worked on development of aviation equipment for American Signal Corps.

At the end of World War I, he decided to return to academic field. He accepted a research scholarship at the Cavendish Laboratory, Cambridge University and worked with great scientists like J J Thomson and Ernest Rutherford. He got trained under such greats during this period.

He returned to America in 1920 and joined the University Washington at St Louis as professor and head of physics department. Soon, he was invited at Chicago University. He worked under the chairmanship of Professor Michelson, as head of the physics department. He stayed there for 22 years. He was successful in roping Robert

Millikan as the chairman of the physics department. He was attracted towards the important scientific researches of this great scientist and got interested in the basic research. He also got involved in the indepth research in nuclear physics. He observed and explained the change in the wavelength of X-rays when they are deflected by electrons. Known as the Compton effect, it is caused by the transfer of energy from the photon to the electron. Its discovery in 1922 confirmed the dual nature of electromagnetic radiation as both a wave and a particle. It also went on to prove that the wavelength of X-rays could be increased. Scientists readily accepted this important discovery. In 1927, Compton was awarded the Nobel Prize for his work on scattering (deflection) of X-rays by electrons. He shared the prize equally with C T R Wilson who was awarded the prize for his discovery of the cloud chamber.

Now his attention was drawn to the cosmic rays. He had in 1913 tried to learn about the nature of cosmic rays and conducted research to understand them. He formed a group of scientists to unravel the mysteries of cosmic rays. Such eight groups worked all over the world, to gather information about cosmic rays. They worked in different regions like Arctic, Equatorial, Asia, Europe and South American Regions. For compiling and assessing the results, Compton travelled nearly 50,000 miles or about 80,000 kilometres.

Till 1939, Compton was not much interested in uranium or nuclear fission. But with the discovery of cyclotron by Lawrence and its subsequent scientific and medical application, Compton directed his interest towards it. On the other hand, America had launched the atomic project sensing the World War II situation. Need arose for great scientists and good administrators. Compton was an obvious choice. This project was sanctioned in 1941 by the then President of America, Franklin Roosevelt on

recommendation of foremost scientists of the time, Albert Einstein, Enrico Fermi and Leo Szilar. A core group of scientists was constituted and sufficient funds were allocated. Later on, some defence officers were also included in the team. The project was named Manhattan Project. On the assurance of Enrico Fermi, Compton took this responsibility. It was difficult to build a nuclear reactor. Finally, it was erected in the Chicago Football Stadium. From 1942 to 1945 he was director of the Metallurgical Laboratory at the University of Chicago, which developed the first self-sustaining atomic chain reaction that paved the way for controlled release of nuclear energy. Things worked as per the schedule and the atom bomb was tested successfully. Compton realized that this project could cause huge loss of human life and untold devastation. But he also saw it as a means to stop the on-going war. Ultimately, what followed came to be known all over the world. May be, personally speaking, Compton and other senior scientists may not have felt morally justified in conducting such a research.

After World War II, Einstein, Fermi and Compton along with other scientists advocated use of atomic energy only for the benefit of the society. Compton returned to academics and established three important research centres: (1) Institute of Nuclear Studies (2) Metallurgy Institute and (3) Institute of Radiology. Thereafter, in 1945, Compton became Chancellor of the University of Washington and then professor of natural history there from 1953 to 1961. During the war, Compton was at the forefront of decision making process on several important science related issues. Many held him as one of those responsible for the atomic massacre in Japan. He believed that the radiation emitted at the time of nuclear fission is a natural process. The use of science for the benefit of humankind is indeed the need of the hour. He died at the age of 70 on March 15, 1962, in Berkeley, California, USA.

58

Enrico Fermi

Enrico Alberto Fermi was born in Rome, the capital of Italy, on September 23, 1901. His father, Alberto Fermi had no formal education, but with sheer hard work and sincerity he had reached the post of a regional head of the railroad. Enrico's mother was a primary school teacher. Enrico was the youngest child among three Fermi children born in three consecutive years. He was an energetic and imaginative student prodigy in high school and decided to become a physicist. His mother did not keep well at the time of his birth. So, he was sent to the countryside. He returned after three years to meet his elder brother and they got along very well. They made many toys, including various models of airplanes and battery driven cars.

When Enrico was 14, his elder brother met an untimely death. This incident saddened him. It was a shock to his mother, who could not bear this loss. Shy and reserved, Enrico could not imagine a life without his elder brother. However, his elder brother's classmate Enrico Persico came in to fill the void. Not only their names, they also shared interests and views. They started working together on various experiments. Together they developed the theory of gyroscope based on the lines of force of the earth's magnetic field.

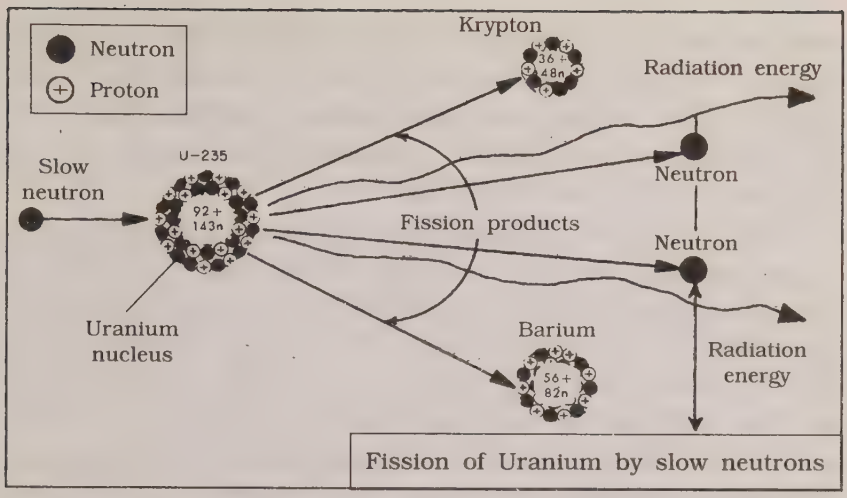
In 1918, at the age of 17, he entered the college, which is associated with the University of Pisa. He wrote a detailed essay on vibrating fibres which earned him a scholarship. Now, he could easily provide for his education. There, he earned his doctorate at the age of 21 with

a thesis on research on X-rays. After a short visit in Rome, Fermi left for Germany with a fellowship from the Italian Ministry of Public Instruction to study at the University of Göttingen under the physicist Max Born, whose contributions to quantum mechanics were part of the knowledge prerequisite to Fermi's later work.

In 1926, his paper on the behaviour of a perfect, hypothetical gas impressed the physics department of the University of Rome, which invited him to join as a professor of theoretical physics. Within a short time, Fermi brought together a new group of physicists, all of them in their early 20s. In 1926, he developed a statistical method for predicting the characteristics of electrons according to Pauli's exclusion principle, which suggests that there cannot be more than one subatomic particle that can be described in the same way. The particles which follow Fermi Statistics are called fermions. Protons, electrons and neutrons are fermions.

Here, he met a Jewish student who later became his life-partner. He married Laura Capone in 1928 by whom he had two children, Nella in 1931 and Giulio in 1936. His research work had geared up. More than 30 of his research papers in various fields were published by 1927. Impressed with his work, the Royal Academy of Italy in 1929, made him the youngest member of the academy. The Italian government conferred on him the title of 'His Excellency' and gave him a special dress reserved for the lords, good income and a sword to carry at royal functions.

His theoretical work at the University of Rome was of vital importance, but fresh discoveries prompted Fermi to turn to experimental physics. In 1932, the existence of neutron, a neutral particle was discovered by Sir James Chadwick at Cambridge University. The nucleus of an atom consists of protons and neutrons. In 1933, Fermi put forward the theory of beta decay in which a neutron becomes a proton by emitting an electron and antineutrino.



Fission of Uranium by slow neutrons

In 1934, Frédéric and Irène Joliot-Curie in France were the first to produce artificial radioactivity by bombarding elements with alpha particles, which are emitted as positively charged helium nuclei from polonium. Inspired by this work, Fermi thought of an idea of inducing artificial radioactivity by another method: using neutrons obtained from radioactive beryllium, but reducing their speed. Passing them through paraffin, he found the slow neutrons were especially effective in producing radioactive isotopes. He used this method successfully on a series of elements. When he used uranium (atomic number 92) as the target of neutron bombardment, however, he obtained radioactive substances that could not be identified.

Fermi's colleagues were inclined to believe that he had actually made a new, transuranic element of atomic number 93; that is, during bombardment, the nucleus of uranium had captured a neutron, thus increasing its mass number followed by beta decay to give the element with atomic number 93. Fermi did not make this claim, for he was not certain what had occurred; indeed, he was unaware that he was on the edge of a magnificent discovery the world was unaware of. He modestly observed years later, "We did not have enough imagination to think that a different process of disintegration might occur in uranium

than in any other element. Moreover, we did not know enough chemistry to separate the products from one another." One of his assistants commented that "God, for His own inscrutable ends, made everyone blind to the phenomenon of atomic fission."

Before this, the Fermis went on a lecture tour round the world. They went to Michigan University for a lecture series in 1930. In 1934, they visited Brazil and Argentina. Meanwhile, the political scene in Italy was changing drastically. Hitler and the Nazis in Germany and Mussolini and the Fascists in Italy had become all powerful. The anti-Jewish slogans on the wall disturbed Fermi because his wife was a Jew.

In December 1938, Fermi was invited to Sweden for receiving the Nobel Prize in Physics. He took permission for himself, wife, two children and their governess to visit Sweden. Sensing the tricky political situation in Italy, he decided to go directly to New York instead of Italy. He had already secured a post at Columbia University. Thus, he continued his work in America.

Meanwhile, in 1938, three German scientists repeated some of Fermi's early experiments. After bombarding uranium with slow neutrons. Otto Hahn, Lise Meitner and Fritz Strassmann made a careful chemical analysis of the products formed. On January 6, 1939, they reported that the uranium atom had been split into several parts. Meitner, a theoretical physicist, secretly slipped out of Germany to Stockholm, where, together with her nephew, Otto Frisch, she explained this new phenomenon as a splitting of the nucleus of the uranium atom into barium, krypton and smaller amounts of other disintegration products.

Meitner realized that this nuclear fission was accompanied by the release of stupendous amount of energy by the conversion of some of the mass of uranium into energy in accordance with Einstein's mass-energy equation, that energy (E) is equal to the product of mass

(m) times the speed of light squared (c^2), commonly written $E = mc^2$.

Fermi, learnt of this development soon after arriving in New York and realizing its far reaching implications, rushed to greet Niels Bohr on his arrival in New York City. The Hahn-Meitner-Strassmann experiment was repeated at Columbia University, where, after a lot of thinking, Bohr suggested the possibility of a nuclear chain reaction. It was agreed that the uranium-235 isotope, differing in atomic weight from other isotopes of uranium, would be the most effective isotope for such a chain reaction.

Fermi and other eminent scientists like Leo Szilard and Eugene Wigner felt that world peace would be endangered if Hitler's German scientists use the principle of the nuclear chain reaction to produce the atom bomb. They drafted a letter, which was signed by Einstein. On October 11, 1939, the letter was delivered to the then American President Franklin D Roosevelt, alerting him on the emerging dangers. Roosevelt promptly acted on their warning and sanctioned the famous 'Manhattan Project' in 1942 to produce the first atom bomb.

Fermi was assigned the task of producing a controlled, self-sustaining nuclear chain reaction. If we burn a piece of paper, it catches fire at one corner, then the sides and ultimately the entire area. The chain reaction is similar to this process. He designed the necessary apparatus, which consisted of graphite and heaps of uranium and uranium oxide. He used approximately six tons of metal in it. He also inserted cadmium strips into it to control the speed of the process. It was named atomic pile by Fermi. On December 2, 1942, Fermi led the team of scientists who, in a laboratory established in the squash court in the basement of Stagg Field at the University of Chicago, achieved the first self-sustaining chain reaction.

Let us see the chain reaction from close quarters. A neutron collides with the uranium nucleus and with

a blast it divides it into two parts, creating energy. At this time two or three neutrons are ejected and a large amount of energy is released. The new neutrons then go on to repeat the same process with other nuclei. This process continues. Thus, fission of the nuclei takes place producing immense energy.

The testing of the first nuclear device, at Alamogordo Air Base in New Mexico on July 16, 1945, was followed by the dropping of atomic bombs on Hiroshima and Nagasaki on August 6 and 9, 1945, respectively.

At the Metallurgical Laboratory of the University of Chicago, Fermi continued his studies of the basic properties of nuclear particles, with particular emphasis on mesons, which are the quantized form of the force that holds the constituents of the nucleus together. He worked as a consultant in the construction of the synchrocyclotron, a large particle accelerator at the University of Chicago. In 1950, he was elected a foreign member of the Royal Society of London.

Fermi made highly original contributions to theoretical physics, particularly to the mathematics of subatomic particles. Moreover, his experimental work in neutron –induced radioactivity led to the first successful demonstration of nuclear fission, the basic principle of both nuclear power and the atomic bomb. The atomic pile in 1942 at the University of Chicago released for the first time a controlled flow of energy from a source other than the Sun; it was the forerunner of the modern nuclear reactor, which releases the basic binding energy of matter for peaceful purposes. Fermi's name has been commemorated in physics in various ways. Element 100, fermium and the unit of length 10^{-15} metre the fermi, were named after him, as was the National Accelerator Laboratory, Fermilab, at Batavia, near Chicago.

It is a general belief in the world of scientists that two masterminds worked towards the attainment of

this dream project–Albert Einstein and Enrico Fermi. The American Atomic Energy Commission awarded Fermi $25,000 in November 1954, for his contribution in the development of an atom bomb. He died of cancer just 12 days later. Today, scientists are working to use radiation to cure the disease that killed Enrico Fermi.

59

Robert Oppenheimer

One who gained fame at a very young age, Dr Robert Oppenheimer was born in New York on April 22, 1904. He was fond of collecting rock samples since his childhood. He also liked to study microorganisms with a homemade microscope. Painting and music were his forte. His parents were well-to-do German-Jewish immigrants who had made fortune by importing textiles in New York City. They paid proper attention to their son's needs and admitted him to the best school.

When he was 12, chemistry attracted his attention. His father encouraged him by setting up a small laboratory at home and by engaging a good tutor for him.

After clearing his school grade with a first class first, he travelled to Europe with his father. Here, he was exposed to various religions and cultures. During this period he also gained command over Greek, Spanish, French, Italian and Latin languages.

Returning from Europe, 19-year-old Oppenheimer entered Harvard University and completed his course in three years instead of the usual four and graduated with a first class. At 22, he joined the Cavendish Laboratory, Cambridge University. Here, he got an opportunity to work with Rutherford, who had contributed immensely towards the study of radioactivity and nuclear physics. He was working on the immense energy produced by the fission of the nucleus of an atom. Oppenheimer also came in contact with the great physicist Max Born and Paul Dirac. On Born's advice and invitation, Oppenheimer decided to go to Göttingen University, Germany to work under the great mathematician. Both worked together to master mathematics and produced important research papers on quantum theories. Oppenheimer completed his doctorate there. He then moved to Zurich and worked there for some time. In Europe, Oppenheimer studied under Werner –Heisenberg also. In 1928, he returned to America, a successful 24-year-old young man.

In America, he worked as professor at California University at Berkeley and the California Institute of Technology. He got married and settled there. He concentrated totally on academics. Besides, he worked on atomic fission. He taught advance physics and mathematics to the students. His reputation attracted students and scientists from various countries. In association with a colleague Mellah Philips, he put forward the 'Oppenheimer-Philips Theory'. The theory was the base for the discovery of heavy hydrogen nucleus.

World War II began in 1939. Einstein and other scientists had understood the aim of Nazi Germany. They had apprised President Roosevelt about the possibility of German and Italian scientists working towards making of an atom bomb. Such a bomb could destroy the world and establish Nazi rule over the world. They felt that it was necessary for America to make such a bomb and end the

World War II. The Manhattan Project, a secret mission to build an atom bomb, was launched in 1942. Oppenheimer was appointed to head the entire project, as he was the head of the Manhattan Committee.

Los Alamos in New Mexico was choosen as the place for producing the atom bomb. The top-secret project began with the best scientific minds getting to act together. The group of scientists included Enrico Fermi, Neils Bohr, Hans Bethe, Arthur Compton, Von Neumann and many others. President Roosevelt had earmarked $ 2 billion for the project. The work on chain reaction was carried out at Chicago University. About 75,000 miners were busy extracting uranium at Oakridge, Tennessee. Oppenheimer was to look into every aspect of this confidential project.

July 16, 1945 was set for the test day of the atom bomb. A 32-ton 100 feet steel tower was erected on Gyro Hill and the bomb placed on it. At 5.30 pm from a control room 14.5 km away in the desert, a remote control button was pressed. The project head Oppenheimer and all the scientists were present at the site. As the button was pressed, a gigantic fireball rose up to 7 miles in the sky and an ear-splitting blast was heard. It was heard 450 miles away in Amarillo, Texas.

The 100 feet steel tower melted away and the sand in that area was converted into green glass. All life in a radius of 1.5 km had been totally destroyed. These things happened due to the immense energy produced by the atom bomb. The scientists were satisfied with the result. Their aim was to put an end to World War II. Keeping the larger picture of the people in mind, the test was kept a secret, as it was not advisable to publish the news at that stage.

On August 6, 1945, American aircraft dropped atom bombs on Hiroshima and later on August 9, 1945 on Nagasaki in Japan. The destruction was unimaginable,

but at same time, it forced Japan to surrender immediately, putting an end to World War II.

When the war ended, Oppenheimer appealed to the government to use atomic energy only for the betterment of society. In 1947, Oppenheimer was appointed director of the Institute for Advanced Study at Princeton, New Jersey and became Albert Einstein's successor. On Oppenheimer's recommendation, President Kennedy announced the $50,000 'Atomic Energy Commission Award' in 1963. The award was later renamed 'Enrico Fermi Award' to immortalize the great scientist. This award is given every year to a deserving scientist.

In 1967, at the age of 63, Oppenheimer died due to throat cancer. He never regretted his association with the Manhattan Project. He believed that whatever he did was to help his nation win over Hitler and the Nazis. Thereafter, he always insisted on the peaceful use of atomic energy to help make the world a better place. Today, the world remembers him as the father of the first atomic bomb, who completed this project successfully within a short span of three years.

Published by Navneet Publications (India) Ltd., Dantali, Gujarat.
Printed by Jagman Enterprise (Offset), Ahmedabad. Tel. 5359993

04 01

About the Author

Prof Suresh R Shah graduated in physics in 1949 from Gujarat College, which was then affiliated to Mumbai (Bombay) University. Later, he conducted research under the guidance of Prof Ramanathan, one of the foremost Indian scientists, at Physical Research Laboratory (PRL), Ahmadabad. He completed his MSc from Gujarat University in 1954.

From 1951 to 1986, he was a lecturer and then professor of physics at M G Science Institute, L D Engineering College, B D College at Ahmadabad along with Gujarat Agricultural University, Navsari. He served as professor as well as the Head of the Department of physics. He also served as visiting professor at Nadiad, Bhadran, Patan and Visnagar University Post-graduate Centres.

From 1972 to 1977, he conducted research as Hydrologist at PRL. He has attended and presented research papers at International Water Management Conference, Chennai (Madras) and National Water Science Congress, Roorkee University. Apart from these, he has actively participated in several seminars and conferences on water management.

He has authored many textbooks and reference books. He has also rendered his services as translator for Halliday & Resnick Physics Part–I with Prof (Dr) Arunbhai Vamdutt. He has co-edited Dictionary of Physics and Dictionary of Astronomy. He has authored books for National Book Trust of India and Gujarat Science Academy, and has writte 100 essays and scientific articles. The Gujarat Sahitya Ac Gandhinagar and Gujarat Sahitya Parishad have hon him thrice with prizes for his excellent books on science. He is the associate member of Gujarat Science Academy. His writings are regularly published in eminent journals and magazines like 'VIGYAN DARSHAN' and 'KUMAR'.

ISBN 81-243-111
9 788124 311141
G 3665